POWER

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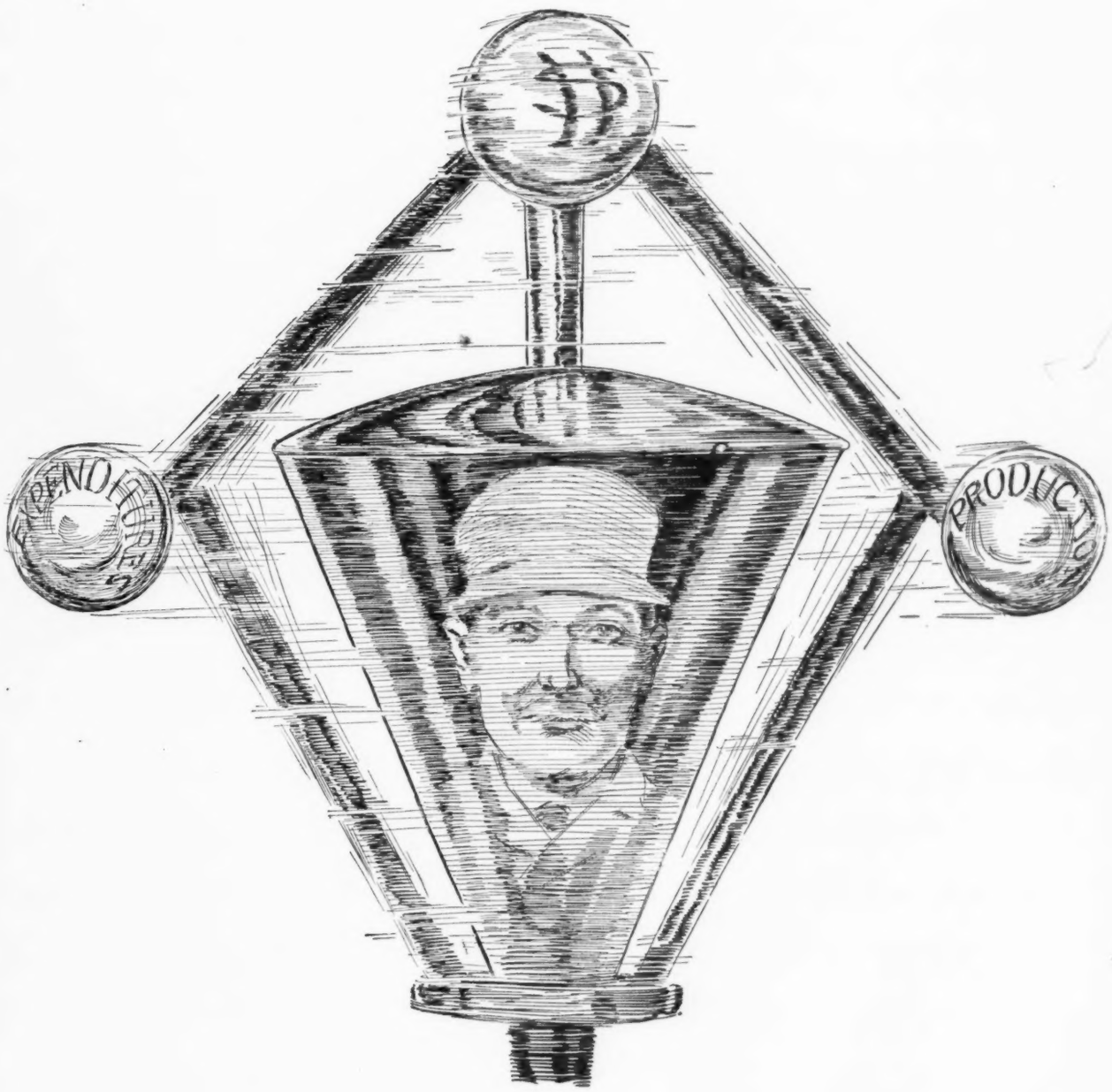
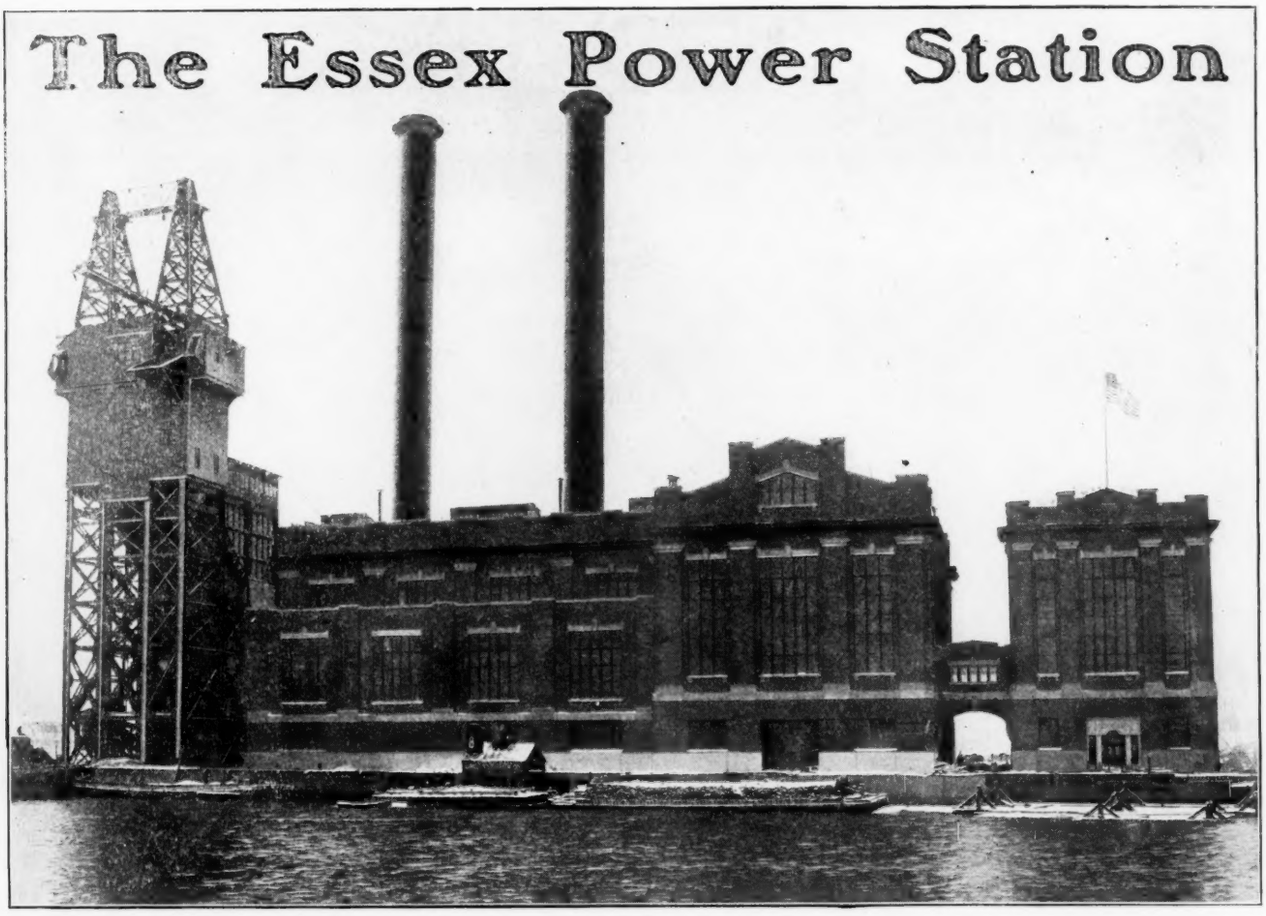


A Good Governor

Drawn by Carl H. Greene

The Essex Power Station



SYNOPSIS—A 50,000-kv.-a. power station built on the unit system, with provisions made for an ultimate capacity of 200,000 kv.-a. In the construction of this plant a world's record was established for power-house construction, and in its design every refinement is embodied that will insure efficient operation and continuity of service. The equipment throughout is the most complete ever installed, and includes in many cases entirely new schemes of control and operation.

The Essex Power Station of the Public Service Electric Co. of New Jersey is situated on the southwest bank of the Passaic River at Point-No-Point, about 2½ mi. west of the company's Marion Station. This new plant forms part of the very extensive system operated by the company throughout the State of New Jersey, supplying both a commercial and traction load. The system comprises 17 power houses having a combined capacity of 197,800 kw., feeding 63 substations through a network of 260 mi. of underground cable and 425 mi. of overhead lines. All the large stations operate at 13,200 volts three-phase, both 25 and 60 cycles. In 1913 the last extension was made to Marion Station, and it became necessary to make provisions to take care of the increasing power demand and also for the future. Of all the sites available, this one was chosen on account of its nearness to the load center, abundance of circulating water, convenient facilities for receiving coal and ample coal-storage space.

The foundation of the present plant and dock rests on about 10,000 piles driven to a depth of 35 ft. The foundations were completed Jan. 21, 1915. Eight months and eight days afterward (Sept. 29, 1915) the first machine was put in operation and was ready to supply 25,000 kv.-a. into the system, creating a world record for speed in power-house construction—an 85,000-kv.-a. building with 50,000 kv.-a. capacity installed. Figs. 9 and 10 show the results of eight months and eight days of construction work.

In the design of the Essex Station every refinement is embodied that goes to promote efficiency in operation and to insure continuity of service, and the station will contain six generators when completed. The plant is laid out for an ultimate capacity of 200,000 kv.-a. The method of

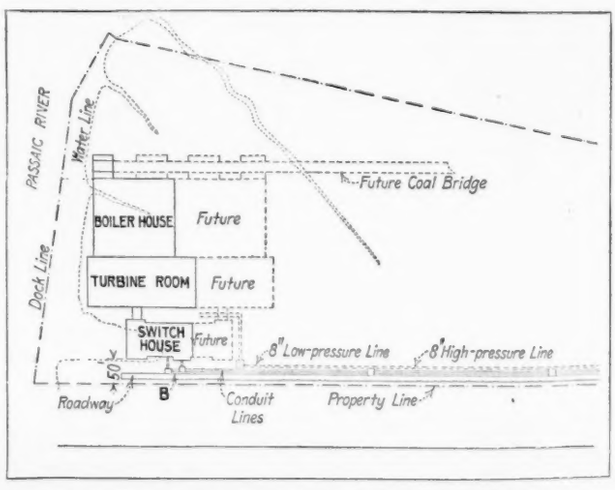
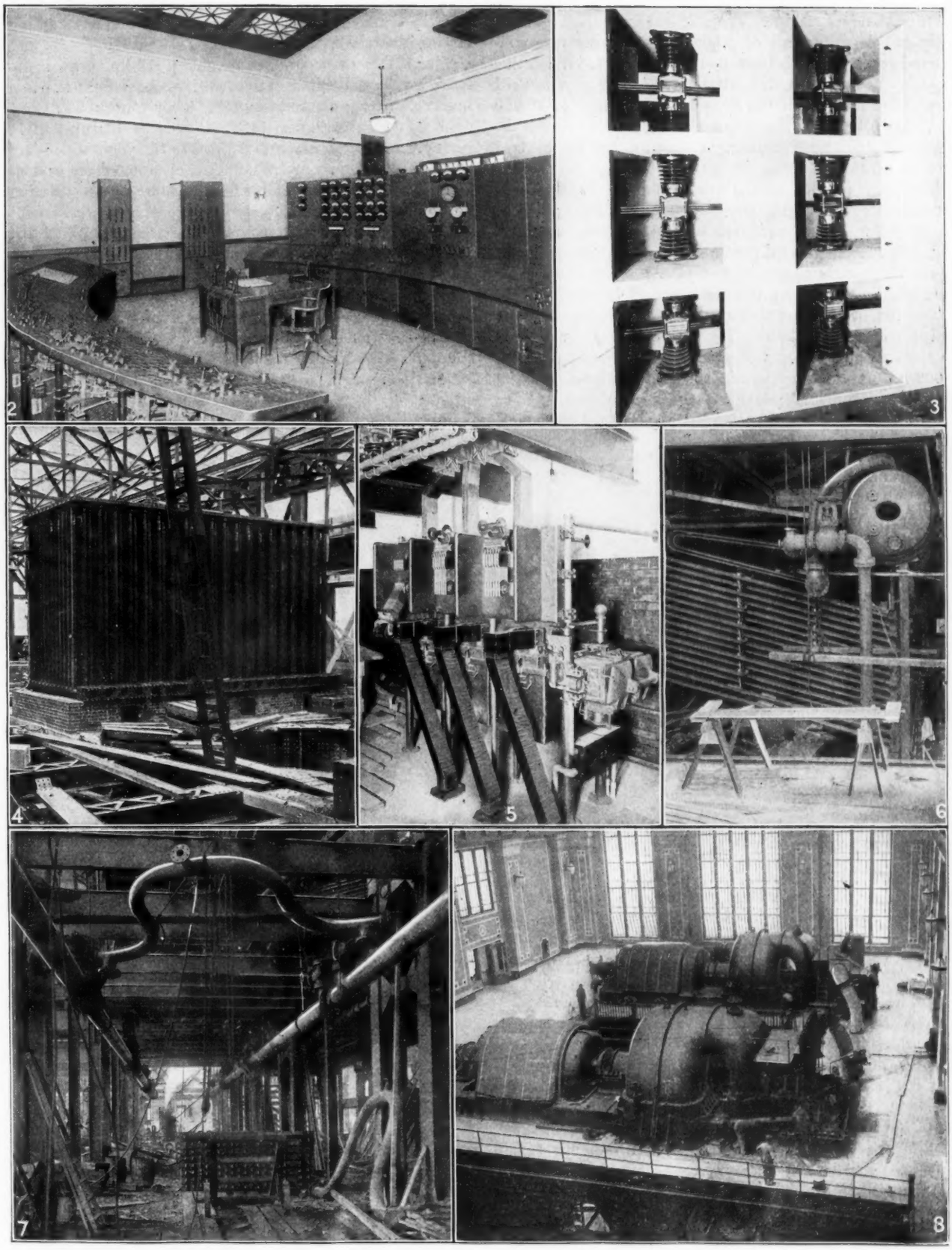


FIG. 1. PROPERTY AND BUILDING LAYOUT



FIGS. 2 TO 8. VIEWS OF DIFFERENT PARTS OF THE INSTALLATION

Fig. 2—Main switchboard. Fig. 3—Method of supporting busses. Fig. 4—One of the economizers in place on its foundation. Fig. 5—Secondary connections of 3,000-kv.-a. station-service power transformer. Fig. 6—Side view of one of the boilers. Fig. 7—Steam headers under boiler-room floor. Fig. 8—Turbine room, showing two 25,000 kv.-a. units installed.

operation will be to run this station in parallel with the other stations on the system and keep the largest and most economical machines operating at their most efficient ratings. A third unit of 35,000-kv.-a. capacity is contracted for, and will be installed during 1917. When this unit is in operation, the station will have a range of capacity of from 25,000 to 85,000 kv.-a. in steps of 10,000 and 15,000 kv.-a., which will make it possible to keep the machines that are running operating at their most economical load.

The plant is built on the unit system in what may be considered four separate structures: Switchhouse, turbine room, boiler house, and coal bunkers and coal bridge. Fig. 1 shows the general plan and indicates that only part of each structure is complete at the present time. The four buildings occupy a total frontage of 401 ft.

The top of the coal tower is 215 ft. above high water and it has a lift of 156 ft. The tower with the bunkers is on the east side of the boiler room and is equipped with a 600-hp. hoisting engine of the two-drum type, built by the Maine Electric Co., and has a capacity of 180 tons per hr. when using a 1.5-ton clamshell bucket. Later on, a 2-ton clamshell bucket will be installed. This will increase the capacity of the hoist to 240 tons per hr. The hoisting speed is 1,300 ft. per min. When the bucket is dropping, it is driving the motor as an induction generator and pumping back into the line. The hoisting engine is driven by a 600-hp. General Electric induction motor.

Coal, after being hoisted to the tower, goes into a hopper from which it passes through a feeder into the crusher and is then distributed by a belt conveyor to the bunkers. The crushers and conveyors were supplied by the Robins Conveying Belt Co. The conveyors are driven by Westinghouse induction motors and are automatically cut out by push-buttons placed in convenient locations along the conveyor runway. Provisions are also made for unloading coal directly from cars or barges to the storage yard and for reclaiming the coal from the storage yard. All the coal-handling machinery is driven by induction motors.

The bunkers have a capacity of 2,000 tons and are built of reinforced concrete supported on the steel structure of the building. From the outside bunkers the coal is brought by means of 15-ton motor-driven weighing larries built by the Robins Conveying Belt Co., one in each firing aisle, and distributed to the stoker hoppers. Each hopper will hold seven tons of coal which is weighed automatically as it is distributed from the larry. One of the weighing larries is shown in the firing aisle in Fig. 11.

The boiler room contains eight 1,373-hp. cross-drum marine-type Babcock & Wilcox water-tube boilers working under a steam pressure of 225 lb. They contain 672 tubes 4 in. by 18 ft. arranged 42 tubes wide by 16 tubes high, giving a heating surface of 13,723 sq.ft. The boilers are guaranteed to evaporate 41,200 lb. of water from and at 212 deg. F. per hour and will give 300 per cent. rating with clean heating surfaces. There are also two rows of circulating tubes which connect the upper ends of the front headers to the steam drum, as indicated in Fig. 6. Each boiler is equipped with six 4.5-in. Crosby safety valves arranged in three pairs so as to blow into a common header, which is piped through the roof. They are also equipped with 2 steam-flow meters, 2 steam gages, 2 water columns, 2 feed-water regulators and 2 feed-water inlets.

The firing is done with 16-retort underfeed Sanford Riley stokers, the largest ever constructed. The drive equipment for each firing aisle consists of four 12-hp. four-speed motors, two driving the mainshaft through a jackshaft and two driving through Reeves conical variable-speed transmissions, giving a mainshaft speed of 32 to 290 r.p.m. This is equivalent to a coal feed of from 1,600 to 15,000 lb. per hr. for each boiler. The furnace has an active grate area of 200 sq.ft.; this gives a ratio of grate area to heating surface of 1 : 63.5. The tubes are 7 ft. 10 in. above the grate at the curtain wall and 9 ft. at the back wall. Each boiler is equipped for forced, natural or induced draft, or all three may be used at the same time. Forced draft for each boiler is obtained by a 60,000-cu.ft. B. F. Sturtevant multivane fan, driven by a 150-hp. motor, which can maintain a 6-in. water pressure under the grates. The air supply to the furnaces is controlled by a Mason regulator. The air pressure under the grates acts upon a flexible diaphragm, which through gears shifts the screws on the Reeves drive, consequently regulating the rate at which coal is fed to the furnace.

Induced draft is obtained by a 100,000-cu.ft. per min. B. F. Sturtevant multivane fan located at the economizer outlet and driven by a 100-hp. motor. The fan gives a 2-in. suction in the uptake of the boilers. After the gases

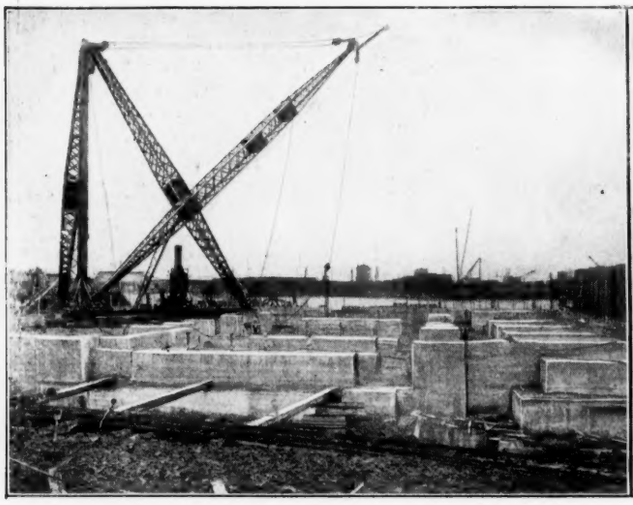


FIG. 9. FOUNDATIONS COMPLETE JAN. 21, 1915

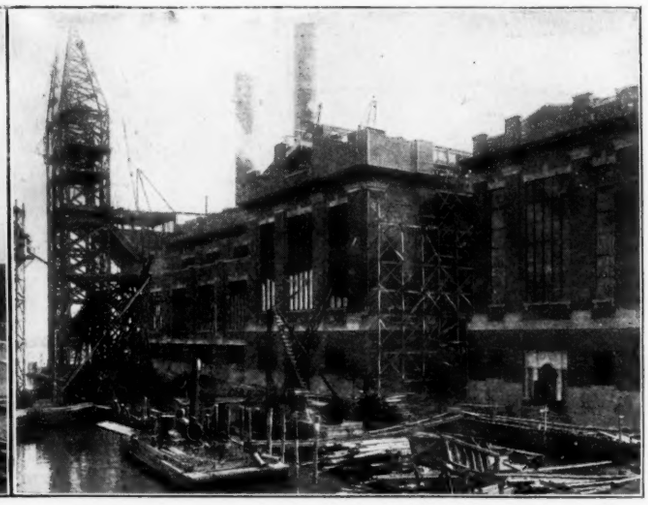


FIG. 10. PROGRESS MADE IN 8 MONTHS AND 8 DAYS

have passed from the boiler, they may go directly to the stack or, by closing dampers in the breechings, can be made to pass through the economizer and then to the stack; by closing a second damper, the gases will pass through the induced-draft fans before going to the stack. This makes it possible to operate the boilers under the most economical conditions at all times.

The economizers were built by the B. F. Sturtevant Co. and contain 480 four-inch tubes 12 ft. long, giving a heating surface of 7,750 sq.ft., which is 56 per cent. of the boiler-heating surface. They are built to stand a working pressure of 300 lb. per sq.in. One of the economizers is shown located on its foundation in Fig. 4.

The stacks are two in number, 250 ft. high above the grates and 16 ft. inside diameter. They are built of steel plates and are of the self-supporting type. They have a 4-in. stack-brick lining with from one to two inches of grout between the brick and the shell.

Drips and drain lines from all sources, as well as the leaders from the roof, discharge into concrete storage tanks beneath the boiler-room floor, and the water so collected is used for boiler makeup. The balance of the makeup water is taken from the city mains. The condensate from each main unit passes through a metering tank provided with a Cochrane V-notch recording meter having a capacity of 4,000,000 lb. per hr. and drops by gravity to a 77,000-lb. storage tank. The makeup water passes through another V-notch recorder, and also goes to the storage tank with the condensate, whence it passes to two 10,000-hp. Cochrane open feed-water metering heaters and then to the boiler-feed pumps at a temperature of 164 deg. F. and is pumped through the economizers into the boilers at a temperature of 244 deg. F. The feed water to each boiler is controlled by two Copes feed-water regulators, which maintain the water level in the boilers constant. A Foster regulator maintains constant pressure difference between feed pressure and steam pressure to turbines on feed pumps. The layout of the feed-water-piping system and economizers is given in Fig. 14. The system is self-explanatory, it will be seen that the layout is very simple for what may be accomplished with it and the last word in flexibility.

The boiler-feed pumps are three in number and were supplied by the International Steam Pump Co. Each pump is 3-stage double suction having a capacity of 1,000 gal. per min. against a total dynamic head of 700 ft. and is driven by a 250-hp. Westinghouse turbine running 2,200 r.p.m.

The boilers blow down through 6 blowdown pipes equipped with a B. & W. and Everlasting valve in series into a tank, thence through a V-notch meter into the sewer.

Very elaborate arrangements have been made in the piping system whereby any turbine or boiler may be tested while in regular service.

All the soot from the economizers, stacks, etc., is taken out by Parsons steam ejectors. The ashes drop from the grates into hoppers, where they fall into side-dump pivot cars and are hauled out into the yard by a 5-ton Baldwin-Westinghouse electric locomotive and are used for filling-in purposes. Provisions have been made so that when the ashes are no longer required for filling purposes, they will be raised by a skip hoist to a bunker in the coal tower and from there discharged into barges.

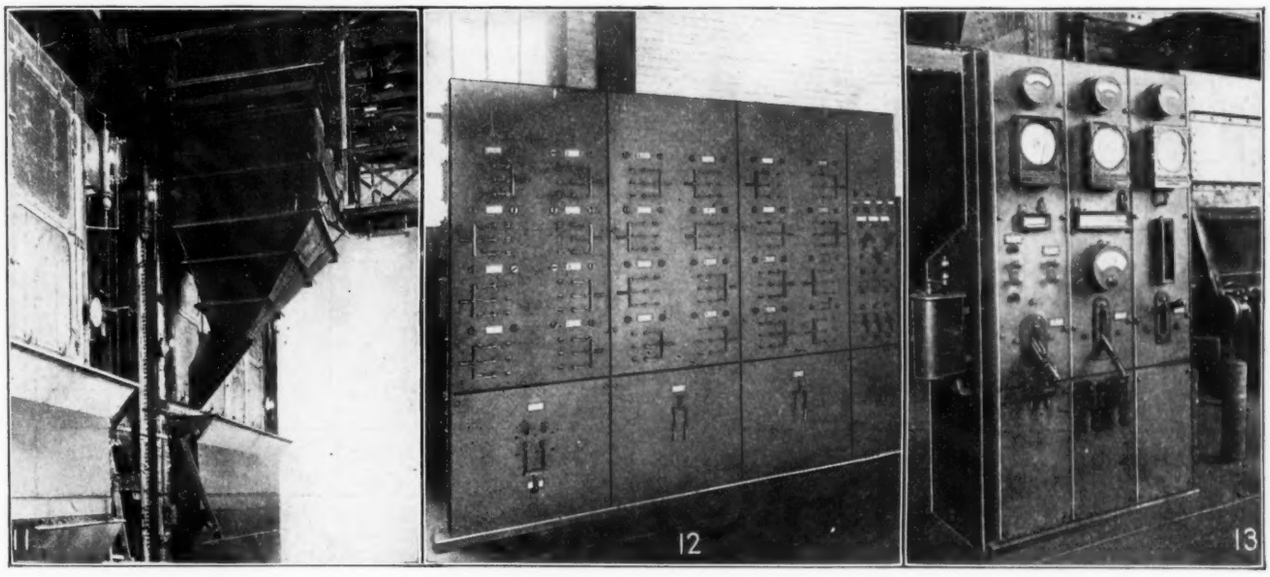


FIG. 11. COAL LARRY IN FIRING AISLE

FIG. 12. SWITCHBOARD FOR THE CONTROL OF STEAM VALVES

FIG. 13. SWITCHBOARD FOR BOILER CONTROL

A switchboard is located in front of each boiler, as shown in Fig. 13, from which are controlled the stoker drive, forced- and induced-draft fans. Indicating and recording meters are also mounted on these panels for draft, temperature, motor current and stoker speed.

All boiler stop valves, sectionalizing valves and turbine stop valves are operated by 125-volt direct-current motors and are controlled from a switchboard, Fig. 12, in the boiler-room engineer's office on the main floor of the boiler room. The turbine stop valves can also be operated from a remote-control station on the main floor of the turbine room. All valves for the feed water and main steam lines were furnished by the Pittsburgh Valve and Construction Co. The auxiliary throttle valves are of Edwards Valve Manufacturing Co. make.

The steam is taken from a double-ended superheater through Edwards stop and check valves into two 8-in. pipes, one at each end of the boiler, down through the boiler-room floor to 12-in. to 18-in. double headers as shown in Fig. 7. These headers are cross-connected at

each connection from the boilers. A 16-in. steam line goes to each turbine and an 8-in. to the auxiliaries. Each end of the superheater is furnished with a 4.5-in. safety valve.

The steam headers are anchored at the center so that one-half of the expansion is in each direction from that point. The headers are also anchored in the turbine-room basement before they connect to the turbine inlet through expansion bends and risers. There are no expansion joints in the headers; they are installed under a tension between anchorages, which causes an elongation equal to about one-half of the expansion of the section from normal temperature to that of the steam. Therefore, when the headers are at the temperature of the surrounding air they are in tension, and when at the temperature of the steam they are in about the same amount of compression. By this scheme it has been possible to do away with expansion joints in the headers, and so far they have worked very satisfactorily. The headers are carried on sling rods with stirrups resting on springs to allow for come and go.

The turbine room, Fig. 8, contains two 25,000-kv.-a. General Electric main units, only one being operated at

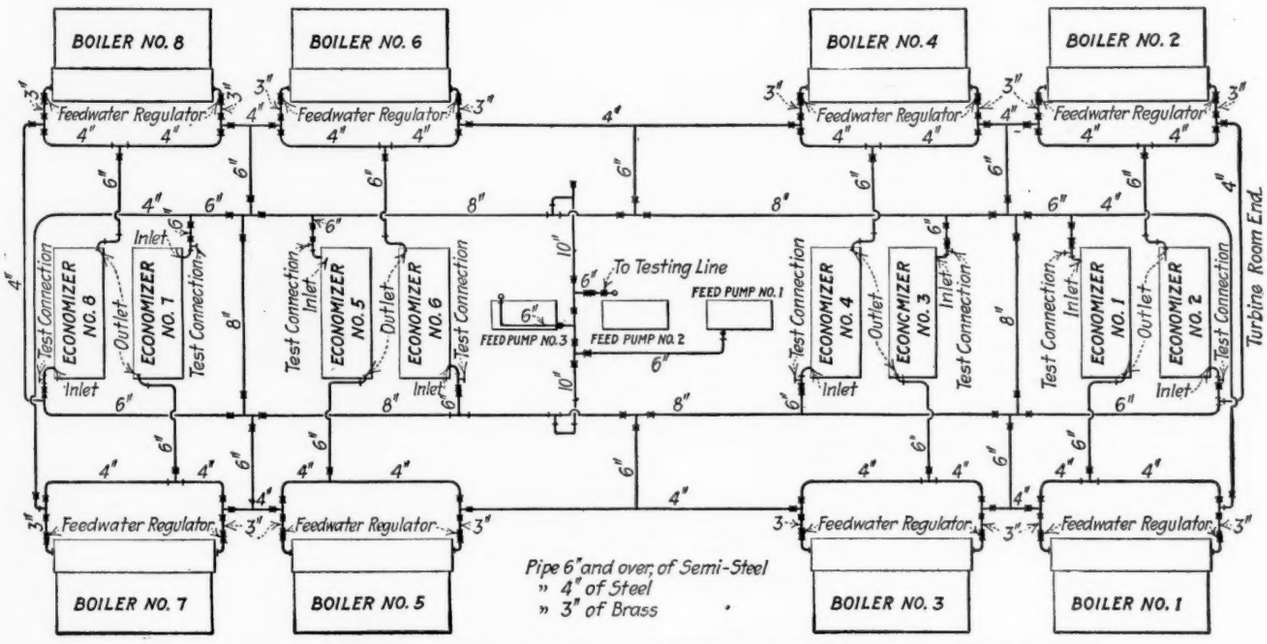


FIG. 14. LINE DIAGRAM OF FEED-WATER PIPING FOR BOILERS AND ECONOMIZERS

a time. Three boilers are required to supply steam for one unit, which gives a ratio of boiler to engine horsepower of 1:8. The main turbines are 12-stage, tandem-compound, with 8 stages for the high pressure and 4 for the low pressure, and exhaust into a surface condenser of the two-pass type containing 6,434 one-inch tubes 19 ft. active length. This gives 1.28 sq.ft. of cooling surface per kilowatt and provides for the condensation of 7.5 lb. of steam per square foot of cooling surface per hour. An average vacuum of 28.73 in. is maintained with 70-deg. circulating water. The condensers are of the radial-flow type and are rigidly connected to the turbines; the expansion and contraction is taken care of by supporting the condensers on springs.

The circulating water is supplied by two 24,000-gal. centrifugal pumps for each main unit, one motor-driven and the other turbine-driven. In the winter the turbine-driven pump usually has capacity enough to maintain the vacuum, making it unnecessary to run the motor-driven pump except during the summer months. The electrically driven pump is so arranged that when the temperature of the discharge water rises above a certain value a thermostat closes, automatically starting the motor, and puts the second pump into service. All the condensing equipment was furnished by the Westinghouse Machine Co.

The vacuum pumps are of the Westinghouse Le Blanc type and are motor-driven. A turbine-drive hotwell pump takes care of the condensate, which is pumped back into a tank whence it passes through a V-notch meter to the feed-water heater. The exhaust of all auxiliaries goes to the open feed-water heaters.

The circulating water is taken from the river through three intake tunnels 9 ft. 4 in. by 8 ft., equipped with motor-driven revolving screens. The discharge tunnels are two in number 12 ft. 6 in. by 9 ft. 4 in., and rest on top of the intake tunnels.

The main generator units are 25,000-kv.-a. (continuous rating) 60-cycle three-phase 13,200-volt machines running 1,800 r.p.m. They are equipped with 100-kw. 250-volt direct-connected exciters. These are the only generators of this speed and capacity that have direct-connected exciters.

The air for ventilating the generators is taken from outside the buildings and is washed by Spray Engineering Co.'s water sprays, one on each generator, directed into the incoming air in several directions. This not only cleans the air, but also cools and humidifies it, the drop in temperature in some cases being as much as 15 deg. F. The air is forced through the ventilating ducts of the generator by fans on the rotor. The heated air from the generator is carried back to the forced-draft fanroom in the boiler house and supplies part of the air for the furnaces, thus recovering some of the losses in the generator.

The exciter system is designed to secure maximum reliability together with independent excitation for each generator, and consists of a regular, emergency and spare. Regular excitation is supplied by a 250-volt shunt generator directly connected to each alternator shaft. In case of trouble on the regular exciter, a low-voltage relay

instantly closes the emergency-exciter circuit, which consists of a 900-amp. (30-min. rating) storage battery equipped with four 14-point end-cell switches, after which the direct-connected exciter is cut out automatically by a reverse current relay. The spare exciter, which is a 75-kw. motor-driven shunt generator, may then be started by the operator from the main switchboard and cut in parallel with the battery on the field of the generator and the battery cut out.

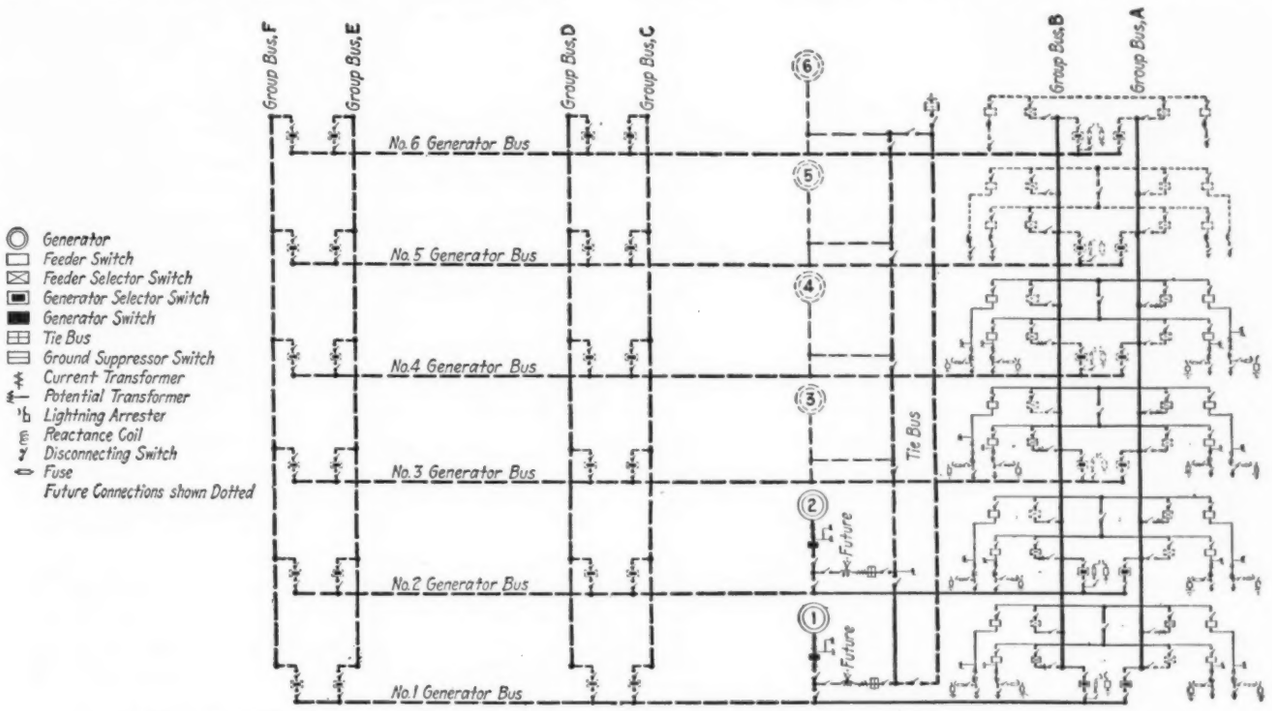


FIG. 15. ONE LINE WIRING DIAGRAM OF GENERATOR, FEEDER AND BUS CONNECTIONS

Fig. 16 shows the scheme of exciter connections for the present installation. Circuit-breakers Nos. 1, 2 and 3 for each generator field are mounted on panels near the main units and are electrically operated from the main control board in the switchhouse. Normally, circuit-breaker No. 1 is closed and connects the regular exciter to the fields of the alternator. In case of trouble, circuit-breaker No. 2 closes and connects the battery to the generator field, after which circuit-breaker No. 1 opens automatically.

The reverse-power relays are so connected that when they open the main switch on the alternator they also open any of the exciter circuit-breakers that may be closed. The alternator's main oil switch is nonautomatic except in case of trouble within the machine itself. The voltage of the exciter battery is maintained at the required value by a contact-making voltmeter. As indicated in Fig. 16, aluminum-cell arresters *AA* are connected across the field terminals of each generator to absorb any discharge in the generator-field circuit. They are also connected across the field circuit of the exciter to prevent reversal of polarity due to the discharge from the alternator field in case of a sudden drop in the exciter voltage.

The bus scheme is shown in Fig. 15. It is laid out for an ultimate of 6 generators and consists of 2 loop tie busses, 6 generator busses (each generator feeds into its own bus through a main oil switch) and 6 feeder group busses of 11 feeders each connected through feeder-selector oil switches, feeder oil switches and feeder reactance coils. In the layout of this bus scheme the principles of the old arc board have been adapted to a new application, and it is the most flexible layout known. When the six generators are installed, there will be six selector oil switches per generator, which will make it possible to connect any generator bus directly to any one or more of the six group busses. The method of supporting the busses is shown in Fig. 3.

The control switchboard, Fig. 2, is located on the sixth floor of the switchhouse and at present consists of 65 panels. Each of the two main switchboards, one the generator board and the other the high-tension feeder board, is divided into three semicircular rows of panels on opposite sides of the operator's desk, as indicated in the

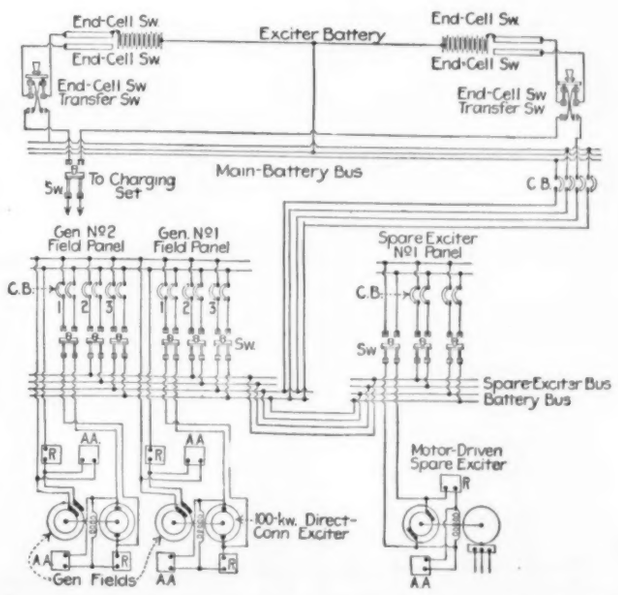


FIG. 16. DIAGRAM OF PRESENT EXCITER CONNECTIONS

figure. On the benchboard are mounted the control switches and indicating devices for the control of the generators and feeder circuits. The row of vertical panels just back of the benchboard carry the indicating meters. On the third row in the generator board are mounted curve-drawing and recording meters. On the third row in the feeder board the protective relays are mounted.

On each of the generator instrument panels is mounted a temperature indicator with a dial switch for connecting it to any of the 12 thermometer coils in each of the generator windings. Each generator recording-meter panel has a watt-hour meter for measuring the total output of the unit, a recording ammeter and a recording temperature indicator.

On an adjacent panel are mounted a recording voltmeter and a recording frequency meter. All the recording meters are synchronized hourly by a master clock, so that the records will be simultaneous.

The synchronous indicators are two in number and are of special designs, being equipped with recording paper. A record is obtained when each generator switch is closed, showing whether it was closed at the correct time. The synchronizing equipment is in duplicate. All switchboard circuits are arranged so that they may be opened for testing by knife-switches on the back of the panels, which obviates disconnecting any wires to test for faults.

The control system is operated from a 125-volt battery, and an emergency is also provided from the exciter battery. The control bus on each panel is separate from that on any other panel. From the control bus there is an individual control feed to each device controlled from that panel. Two emergency-control busses are provided so that in case of failure of the regular feed, the control bus may be connected to one of the emergency circuits.

There are approximately 150 switchboard panels in the present installation. Ultimately there will be 310 distributed throughout the plant. One 50-point multirecorder is being installed at the present time. Provisions have been made to install nine of these devices. The multirecorder is operated from a 25-volt storage battery; this makes a total of three batteries in the plant.

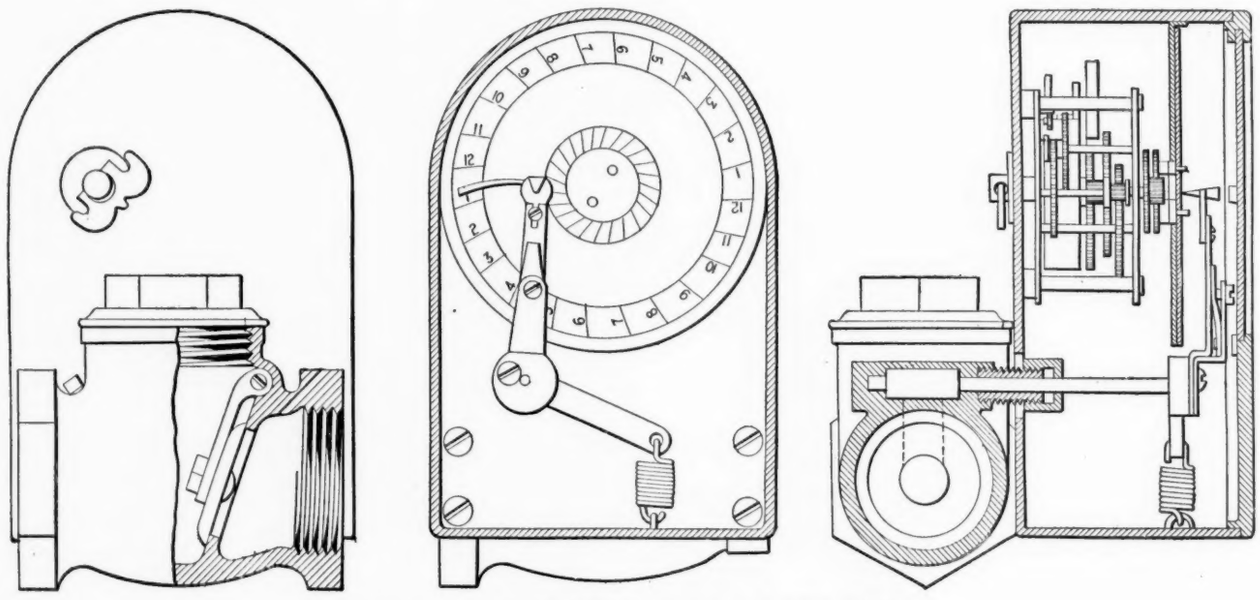
The power for the station is supplied from a 3,000-kv.-a. 13,200- to 440-volt 60-cycle water-cooled, oil-insulated transformer. The secondary connections are shown in Fig. 5. The transformer is equipped with water-flow indicators and thermometers, which operate an alarm in case the transformer has no cooling water or becomes overheated.

All the motors used throughout the plant except those which operate valves are 440-volt machines. A 440-volt system was selected on account of the greater safety to the attendants over a 2,300-volt system and also on account of the great saving in cable and bus capacity compared with 220-volt. Where variable speed is required of the alternating-current motors, it is obtained either by changing the number of poles in the stator winding or by rotor resistance.

The entire design of this plant was executed by the engineering department of the Public Service Electric Co. under the general direction of N. A. Carle, chief engineer. With the exception of installing the large machinery, all construction work was done by this engineering organization; no outside consulting engineers were employed.

Boiler Blowoff Recorder

How many chief engineers know whether their firemen faithfully blow down their boilers at stated intervals and for the proper period? A device has recently been patented by William W. Ricket and Henry R. Frech, of Stowe, Penn., that records every blowing down of a boiler, the time the blowoff is opened and when it is closed. This recording instrument is a telltale as to whether a boiler is being blown down regularly and whether too little or too much water is being blown out.



DETAILS OF THE BOILER BLOWOFF RECORDER

The device consists of a check valve and a clock movement. Attached to the blowoff pipe between the blowoff valve and the outlet is a swing check valve that opens outwardly. Attached to an extended pivot shaft is the valve disk at one end and a scriber arm at the other. Connected to the body of the check valve is a clock case and a movement that revolves a dial. A chart di-

vided into two 12-hr. sections fits on this dial, and the scriber records the movement of the check-valve disk. An arm connected with a spring assists in closing the valve after it has been opened in blowing down the boiler, instead of depending upon gravity. The three views in the accompanying illustration show the details of construction of this blowoff valve recorder.

When the blowoff valve is opened, the check valve is blown open, which action causes the scriber arm to move across the chart from the center to the outer division, as shown by the heavy lines between the figures 12 and 1. The scriber remains at the outer position so long as the blowoff valve is open and moves back to the center of the chart when it is closed.

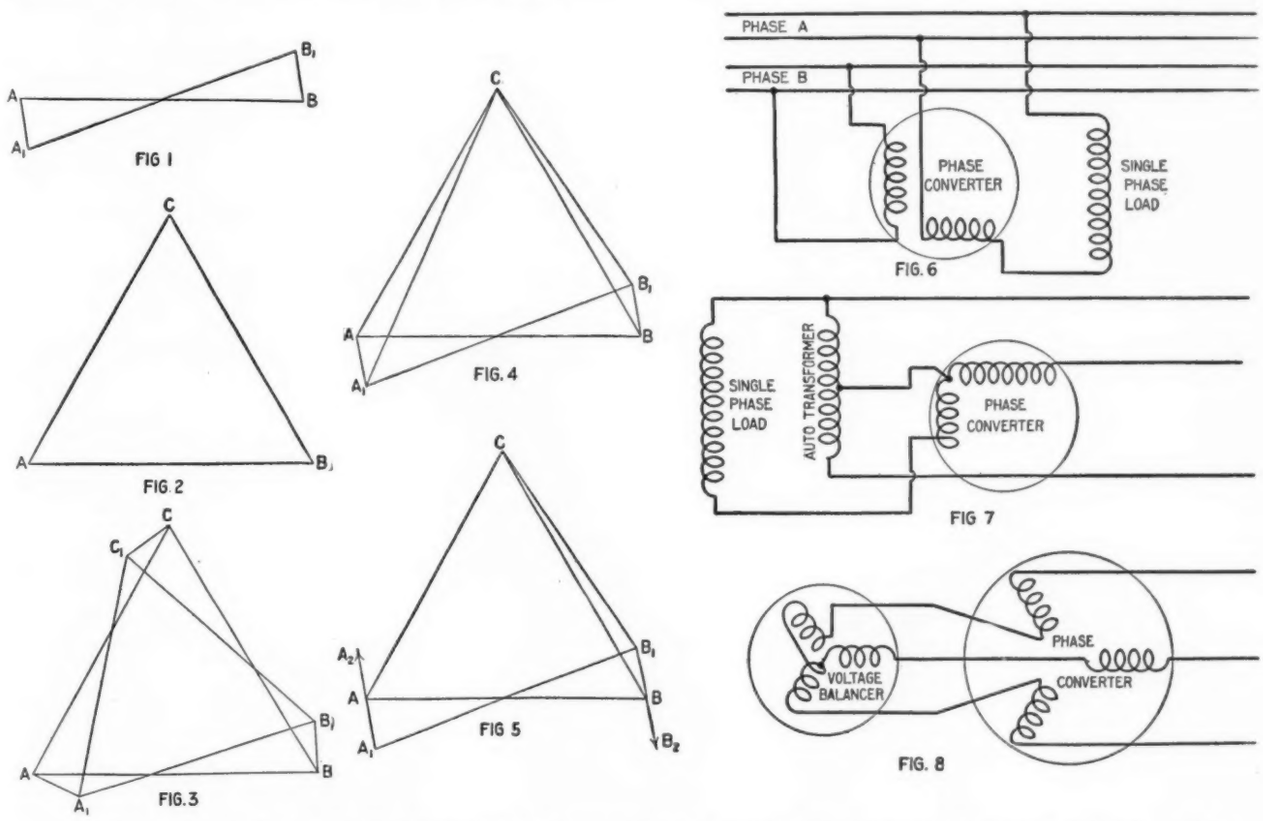
The Shunt Phase Converter

By W. J. Foster

SYNOPSIS—A description is given of the construction and operation of the phase converter with a voltage balancer, a recently developed set of machines which allows taking single-phase load in large proportions from a polyphase system and yet maintaining the voltage and current balance.

The name phase converter has been given to a new type of machine whose function it is to allow single-phase load in large proportions to be taken from a polyphase system without unbalancing the system. The functions of this new machine are just as distinctive as are those of the synchronous or rotary converter, which changes alternating current to direct current or vice versa, or those of the frequency converter, which changes from one periodicity to another.

It is well known that single-phase current in relatively large quantities cannot be taken from a polyphase generator or distribution system without objectionable unbalancing of potentials. The largest factor in the unbalancing is the changed direction of the electromotive force, due to the presence of current in the circuit. In Fig. 1, if the time phase, or direction of the e.m.f. in an unloaded circuit, is represented by the line AB, then it will be represented by the line A_1B_1 with current flowing of such magnitude as to produce a magnetization AA_1 and BB_1. Consider the e.m.f.'s of a three-phase system represented by the equilaterial triangle ABC, Fig. 2. Remembering that a three-phase system is nothing more or less than three single-phase systems, identical in all respects except in the "time" or "phase" element, it is apparent that with equal currents in all three phases, the equilaterial triangle $A_1B_1C_1$, Fig. 3, will represent the e.m.f.'s and that they are in consequence perfectly balanced. On the other hand, with current flowing only in the phase AB, the triangle A_1B_1C, Fig. 4, will represent the e.m.f.'s or potentials of the three phases. The potential of the unloaded phase A_1C is slightly greater and the potential B_1C of the other unloaded



FIGS. 1 TO 8. DIAGRAMS SHOWING EFFECT OF LOADING AN ALTERNATING-CURRENT CIRCUIT, AND THE PHASE CONVERTER

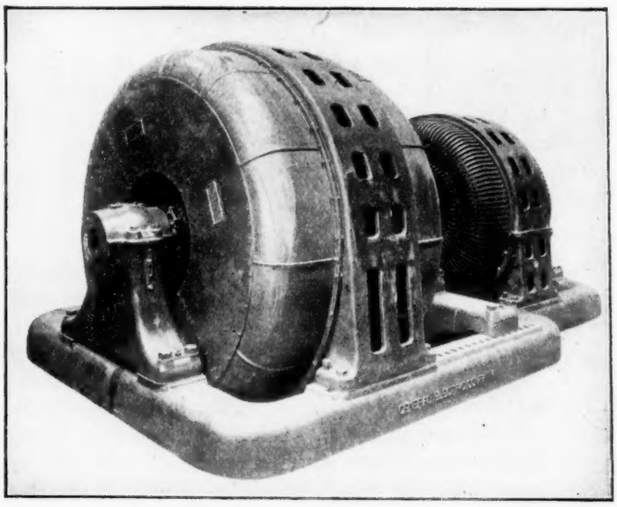
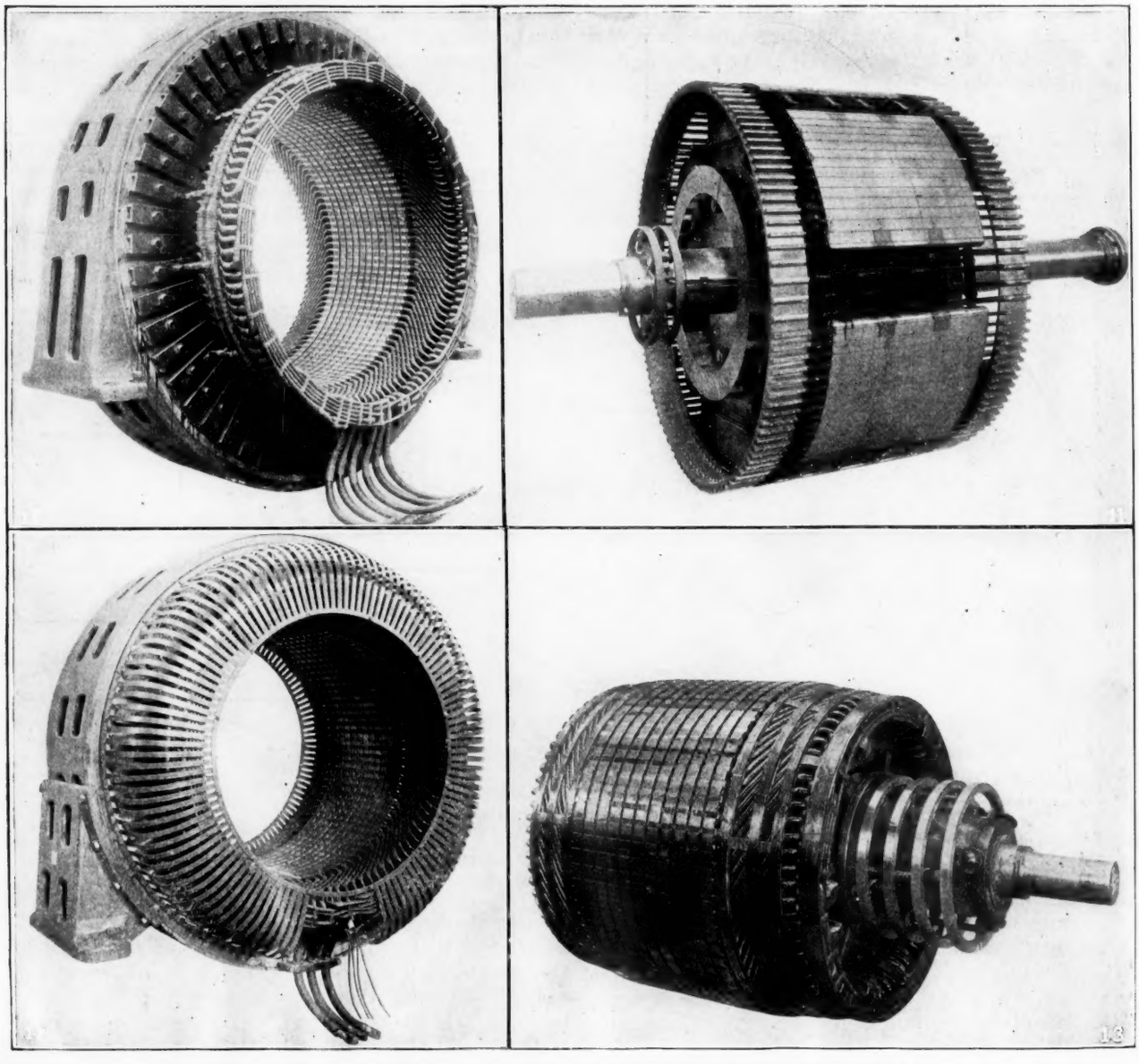


FIG. 9. 5,000-KV.-A. PHASE-CONVERTER SET INSTALLED AT PHILADELPHIA ELECTRIC CO.

phase is slightly less than the potential A_1B_1 of the loaded phase—the characteristic condition so well known to operators. The newly developed machine, the phase converter, is a device whose function it is to offset the effect of the magnetization of the single-phase current by supplying equal and opposite magnetizations AA_2 and BB_2, Fig. 5, which restore the triangle A_1B_1C to its original ABC.

Perhaps the simplest case of phase converter and the application that is easiest to understand is the series converter operating from a two-phase or quarter-phase system, Fig. 6. Here, with proper switches installed, the converter may be started up in the same way as a regular synchronous motor. When synchronized, one of the phases may be opened, reversed and thrown into series relation with one of the phases of the system. The single-phase load may then be thrown on. The voltage of single-phase will be approximately twice that of the two-phase system; the current will be the same as that in each of the two phases. This is exactly analogous to a series transformer.



FIGS. 10 TO 13. ROTORS AND STATORS OF SHUNT PHASE CONVERTER

Fig. 10—Stator of phase converter. Fig. 11—Rotor of phase converter. Fig. 12. Stator of voltage balancer. Fig. 13—Rotor of voltage balancer

The 90-deg. change in direction of e.m.f. is accomplished by the phase converter—a rotating machine in which one phase functions as a motor and the other as a generator.

If the voltage of the single-phase load is other than double that of the supply system, it may be obtained by the use of an auto-transformer in combination with the series-phase converter. Fig. 7 illustrates the case of a single-phase load of the same voltage as the three-phase system from which current is taken. The phase converter here shown is wound two-phase, but for different voltages in the two phases in the ratio $\sqrt{3}:1$. The single-phase load is imposed between one of the three-phase lines and one of the phase-converter terminals, with one-half of the voltage obtained between the three-phase line and tap at the middle point of the auto-transformer, the other half is generated in the phase converter.

Construction and Operating Features

Fig. 8 shows the diagram of windings of the shunt phase converter for operating on three-phase systems. As shown in Fig. 9, this converter consists of a large and a small machine on a common shaft. Both have armatures with perfectly balanced three-phase windings (Figs. 10 and 12) and are similar in their general construction to generators or synchronous motors. The armature windings of the two machines are connected in series, but with the phase rotation of the smaller reversed. The relative size of the two machines is determined by the relation between the correction required to the total electromotive force, or the ratio of AA_2 to AB in Fig. 5. When operating, the currents in the two machines are of same magnitude and the same in all three phases. The larger machine may be designated the phase converter proper and the smaller one the voltage balancer. The illustrations show a 25-cycle 11,000-volt phase converter with voltage balancer, that has been installed in Philadelphia. The normal rating is 5,000 kv.-a. continuously, 6,000 kv.-a. two hours and 12,000 kv.-a. for five minutes. The phase converter proper has a revolving field of the salient pole type, with unusually heavy squirrel-cage winding (Fig. 11). The voltage balancer has a revolving field of the cylindrical or induction-motor type (Fig. 13) with two independent field windings corresponding to a two-phase wound induction-motor field. The excitation is supplied through four collector rings and from two independent exciters. These exciters may be mounted on the shaft of the converter set or independently driven, as in the case of the Philadelphia machines, by a small induction motor. The double excitation on the voltage balancer is made necessary by reason of the change in power factor of the load and in the case of balancing up three-phase system where single-phase loads are taken from different phases. The relative amount of excitation in the two windings is controlled automatically by field regulators. The great advantage of the shunt phase converter over the series converter is that it may be located anywhere in the system and that it preserves the balance for single-phase loads taken between any two of the phases. The size of the converter for any given system is determined by the greatest unbalance that may exist at any time during the day.

The shunt phase converter is well adapted to easy starting. There are different ways in which it may be started up from the line without severe drain on the system. Probably the simplest and best is to make use of the voltage balancer as a starting motor. This requires the addition of an external starting resistance introduced between the collector rings and the use of an auto-transformer with two of the leads reversed when connected to terminals of the balancer armature to give the right direction of rotation.

The field of usefulness for phase converters is great. It is well known that single-phase generators connected to prime movers are much more costly and less efficient than polyphase generators. Furthermore, when located in power houses, as an auxiliary to the polyphase units, they introduce complications and greatly reduce the efficiency of the plant as a whole, since they necessitate operation of the average unit at reduced load and involve the constant no-load losses of more generators and more prime movers. The usual method heretofore of obtaining single-phase current in relatively large quantities as a single load from polyphase systems, without producing unbalancing, has been to introduce a motor-generator set consisting of a polyphase motor and a single-phase generator. This has been a costly method, by reason of the great losses in motor-generator sets. Much thought has been given to the problem of obtaining single-phase current from polyphase distribution systems in such manner as not to disturb the balance by means of stationary apparatus alone. Numerous ingenious connections for transformers and combinations of transformers with reactances, resistances and condensers, have been devised; but as far as known to the author, none of them has been successful.

The generation of single-phase current was the subject of the October meeting of the American Institute of Electrical Engineers in Philadelphia. The author of one of the papers brought out very forcibly the desirability, if not the duty, of a public-utilities company being able to furnish electric current for any and all purposes that might be required by any customer. It was generally agreed by those discussing the papers that the introduction of the phase converter is a great step forward.

CO_2 Chart from Cleveland Plant

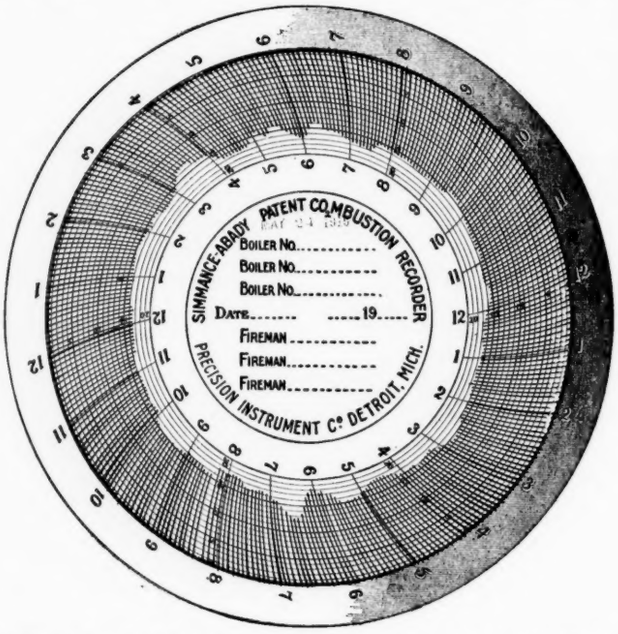
By Charles H. Bromley

An exceptionally good CO_2 chart tells so much that one likes to visualize the boiler room—the coal, the stoker, the boiler settings, the control of the combustion and, most important of all in the final analysis, the men.

The accompanying chart is from the much-discussed Cleveland, Ohio, municipal electric station. Boilers are fired by underfeed stokers, the coal is bituminous, Ohio No. 8 slack, having a heat value of 12,000 to 12,500 B.t.u. with an ash content of 10 to 15 per cent., the sulphur running from 2 to 3½ per cent. The boilers are of the double Stirling type, normal rating 1,000 hp., capable of running at 300 per cent. rating, 275 lb. and 150 deg. superheat. The pop valves are set at 250 lb. The maximum flame travel from the dump plate to the bottom of the middle drum is 31½ ft. The minimum travel of the flame from the top of the grate to the under side of the bottom drum is 5 ft. before the gases impinge upon the heating surface. Using forced induced draft enables the plant to carry a balanced condition in the furnace, thereby eliminating leakage through the settings. The operators are first-class licensed engineers, which bears considerably on the influence of the combustion. During the day the

boilers are run at approximately 175 per cent. ratings and at 100 per cent. rating throughout the night.

It is of considerable interest to know that the CO_2 charts are checked very frequently with the Orsat apparatus and that it is only on exceptional occasions that with CO_2 percentage of 18 a trace of CO is found. In the far greater number of analyses no trace of CO is found.



UNUSUALLY GOOD CO_2 CHART; CLEVELAND MUNICIPAL ELECTRIC PLANT

As an illustration of the influence of the boiler-room crew, or rather those in immediate charge of the stoker, it is interesting to note the exceptionally uniform CO_2 from 8:15 a.m. to 3 p.m. For nearly an hour, between 4 and 5 p.m., presumably with a light load, the CO_2 remains at 17 per cent. A fair estimate of the average between 4 a.m. and 5 p.m. (13 hr.) is 16 per cent. It is obvious that this combustion nearly approaches the theoretical.

The performance as made in Cleveland should indeed be an inspiration to those who believe that the burning of ordinary run-of-mine coal, stoker-fired, can be made to hold its own with prepared fuels of a solid character.

Crane Engine Stop Valve

An emergency engine stop valve, operated electrically or by hand, is being made by the Crane Co., of Chicago. The design is that of a swing check valve with the flow against the back of the disk. Ordinarily the disk is held up out of the path of the steam. It is attached to a shaft which extends through a stuffing-box to the outside of the valve. One end of a lever attached to this shaft rises vertically to the releasing device (hand or electrical), and the other end of the lever extends horizontally, with a weight attached to assist in closing the valve.

Under normal operating conditions the disk is held open by the releasing device, which may be tripped by hand through a chain, or electrically when a solenoid is provided for the purpose. Push-buttons may be located at convenient points, and the engine governor may be equipped with contacts that will close the circuit in case of overspeed of the engine. Provision may also be made to operate the valve in cases of excessive current or voltage or in extremes of steam pressure above or below normal. When the release is tripped by hand, the chain may be located out of the danger zone at a point most convenient to the operator, insuring a quick and safe closing of the valve. As

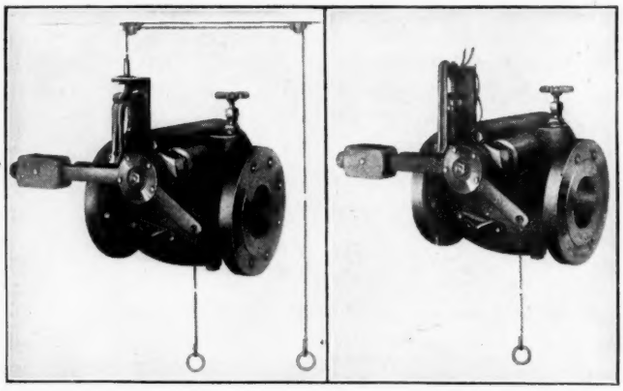


FIG. 1. HAND OPERATED STOP VALVE

FIG. 2. ELECTRICALLY OPERATED STOP VALVE

soon as the tripping device has been released, the weight on the lever brings the disk into the path of the steam and instant closure is the result. A spring prevents undue slamming.

As it would be difficult to open the valve with steam pressure on one side of the disk, a bypass valve has been provided to equalize the pressure on both sides. After closing the engine throttle, this valve is opened. By means of the chain and lever provided, it is then easy to reset the stop valve. Normally this bypass valve is closed.

Manhattan State Hospital's Central Heating Plant

By G. B. Nichols

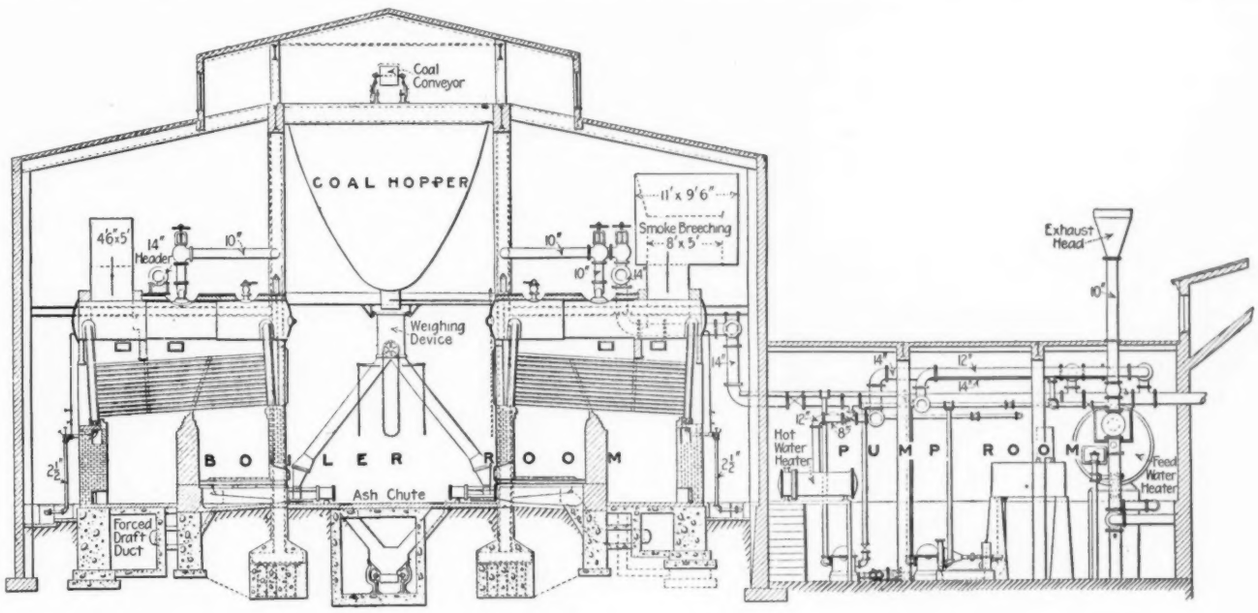
As hospitals for the care of the insane have as a rule been institutions that have grown to meet the needs and systematic development has been entirely lost sight of, a somewhat chaotic condition exists in many of the older and larger ones throughout the country, especially in the heating systems. The Manhattan State Hospital is one of the largest institutions for the care of the insane in the country, having a total of 4,700 inmates. The buildings were heated from three separate power houses until about four years ago, when two of them were combined by installing steam connecting mains. The Department of Architecture for the State of New York, under the direction of Lewis F. Pilcher, state architect, and G. B. Nichols, chief engineer, prepared plans, and contracts were awarded for completely remodeling and enlarging the main power house, abandoning the old boilers and remodeling the space they now occupy for shop purposes. A large addition to the building, consisting of a pump-room, three offices and one large boiler room with new stack, constitutes the new work.

Under the heating contract is to be furnished five rated 600-hp. Stirling type water-tube boilers equipped with American underfeed stokers. All the air ducts from the blowers located at the end of the boiler room are underground. The blowers are direct-connected to vertical engines, each blower being designed to take care of

four boilers with a 50 per cent. overload, each having a total capacity of 55,000 cu.ft. of air per min. against a pressure of two ounces. The engines are 10x10-in., operating at a speed up to 300 r.p.m

Space is provided for three more 600-hp. boilers, and with this future capacity, it is believed that the institution will never grow so as to require another revision in its heating design.

The present addition includes one stack 150 ft. high by 10 ft. in diameter intended to take care of one bank



GENERAL LAYOUT OF BOILER AND PUMP ROOMS OF THE MANHATTAN STATE HOSPITAL, NEW YORK CITY

of four boilers of 2,400-hp. rating and is arranged to take care of the fifth until an additional stack is built.

The boiler house is a brick structure, approximately 120 ft. long, 80 ft. wide and 40 ft. high to the under side of the monitor and at the outside wall. The monitor, 40 ft. wide by 12 ft. high, has windows along the side for cross-ventilation.

The building contractor will furnish an overhead, parabolic, concrete and steel coal and ash bunker, approximately 22 ft. wide by 20 ft. deep to run the entire length of the boiler room, one end partitioned off to receive ashes. The capacity of this bin is about 500 tons.

From below the center of the boiler house a tunnel 8x8 ft., extends to a point 20 ft. from the boiler house, at which point the coal will be delivered from a crusher to a conveyor passing through this tunnel. This conveyor will carry the coal the entire length of the tunnel to the farther side of the power house, up the power-house wall and across the overhead bunker, delivering the coal to any part of the bunker. This conveyor will also be used at certain periods of the day for carrying ashes, which will be dropped through chutes in front of the boilers to the conveyor to be delivered to the ash bin above. All the coal will be delivered from the overhead bunkers through chutes to an automatic weighing device (on a crane traveling the length of the boiler room) and thence through chutes to the stoker hoppers. The amount of labor in the boiler room will therefore be kept at a minimum.

On account of the levels at which the water returns to the power house, it was decided to first deliver it to a circular tank 8½ by 11½ ft. and from this tank the 10-in. returns lead to duplicate 10x12x12-in. return pumps. These pumps deliver the return water to a 5,000 boiler horsepower open-feed-water heater. From the feed-water heater the water is delivered through a V-notch recorder and thence to the centrifugal boiler-feed pumps direct-connected to Curtis turbines, each having a capacity of 225,000 lb. of water per hour against a pressure of 150 lb. All the hot water for the institution is to be heated at the power house by two water-tube water heaters, with a capacity of 15,000 gal. per hr. To equalize the flow, there is in connection with the domestic hot-water system a 42-in. by 8-ft. storage tank and circulation is maintained by duplicate centrifugal pumps, each pump having a capacity of 60 gal. of water per minute against a head of 15 lb. and direct-connected to an induction motor.

The water pressure at the institution being low, it was found necessary to install force pumps to supply water to the upper portions of the building. These cold-water service pumps are of the centrifugal type with a capacity of 1,000 gal. per min. against a head of 60 lb. One pump is connected to an induction motor and the other to a Curtis turbine. The pumps connected to turbines will be run when there is use for all the exhaust steam, and those connected to the induction motors will be run when there is no demand for exhaust.

The present electric plant for lighting the institution consists of three-phase alternators, 2,300-volt 60-cycle, and will not be changed under the present alterations.

About 3,550 tons of bituminous and 19,680 tons of No. 3 buckwheat coal is burned during a year, making a total tonnage of 23,245 and the cost is approximately $46,500. The yearly cost of coal per inmate is $9.90, which is a very low figure for institutional heating. It is to be expected, however, that the new plant, with automatic stokers and coal- and ash-handling apparatus, will not only effect a saving in labor, but will take less coal. The design of the plant will make enlargement possible with but slight additional equipment in the boiler house.

Motor-Operated End-Cell Switch

By D. P. Orcutt*

SYNOPSIS—The function, construction and operation of a large end-cell switch is described, with special reference to its application to emergency batteries.

Where storage batteries are used in large lighting plants or substations as an emergency source of power, some provision must be made to maintain the voltage of the

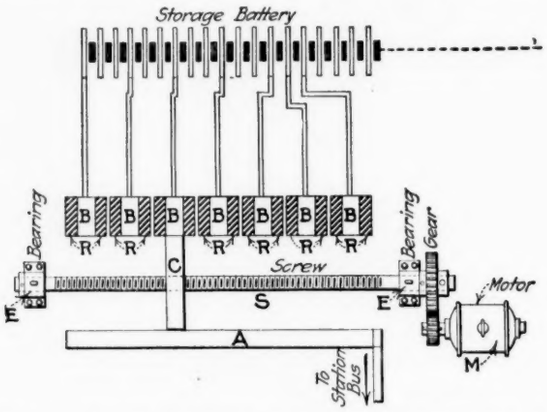


FIG. 1. DIAGRAMMATIC REPRESENTATION OF AN END-CELL SWITCH

battery when called upon to take over the load of the station following a shutdown of the main units.

While a storage-battery cell can discharge at a very high rate, the voltage across the terminals of each cell is necessarily reduced as the rate of discharge is increased, owing to the resistance to the flow of current within the cell itself. If a cell is floating on a circuit neither charging nor discharging and is called upon to discharge, its voltage drops a certain amount depending upon the rate at which current is taken from the cell. The emergency battery in the lighting station is made up of a number of individual cells, usually 150 for a 120- to 240-volt three-wire system. When the station is running normally, about 114 of these cells would be connected across the main busses and the battery would be floating, neither charging nor discharging, with the voltage across the 114 cells reading approximately 240, or the normal voltage of the station. Should there be a breakdown or shutdown of any sort in the station and the battery be called upon to discharge, the voltage of each of the 114 cells in circuit would immediately drop and accordingly the voltage across the line would fall below the normal voltage that should be maintained, thus causing the dimming of lights and the slowing down of motors.

To correct for this drop in individual cell voltage caused by the increase in the discharge rate and to correct for the gradual dropping off in voltage of the cells as they discharge, additional cells must be connected into the circuit. This would be quite easy if the current handled was only moderately large, but it happens that the currents from the immense emergency storage batteries in some of the more important stations run as high as 80,000 amp.

Motor-driven end-cell switches are used to connect additional cells into the circuit for the purpose of maintaining the voltage of the battery at the predetermined station voltage. These switches must not only be capable of carrying an exceedingly heavy current, but must also be able to connect additional cells into or out of the circuit without opening the circuit for even the fraction of a second. It should be remembered also that the large cells used in this service are capable of delivering a tremendous current on short-circuit, so that to actually short-circuit a cell or group of cells in changing the number on the circuit is not to be thought of.

The way in which these problems are solved in practice is illustrated in Fig. 1, which is a diagrammatic representation of the end-cell switch used for this purpose. The screw *S*, supported by the bearings *E* and turned through gears by the motor *M*, carries the contact *C*, which moves forward or backward as the screw is revolved. This movable contact on one side rests on the long stationary contact *A*, which connects to the main bus in the station. On the other side this traveling contact moves over the cell contacts *B* and the intervening resistance contacts *R*. The contacts *B* are connected directly to the terminals of the end cells by heavy copper bars. The number of cells controlled by each point on the end-cell switch de-

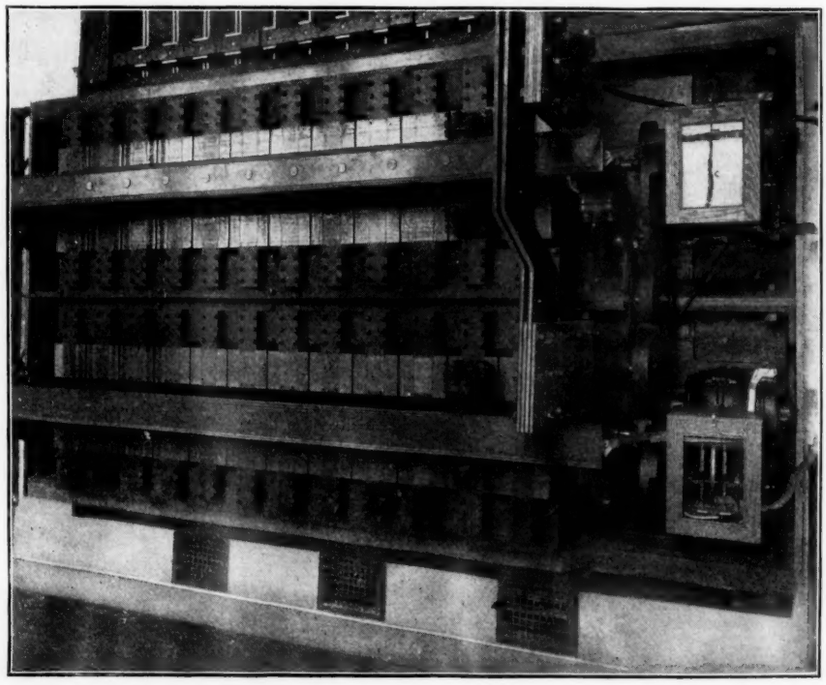


FIG. 2. TWO 10,000-AMP., MOTOR-OPERATED END-CELL SWITCHES

*Electrical engineer, with the Electric Storage Battery Co., Philadelphia, Penn.

pends on the circumstances governing the particular installation; it may be as high as three or four in the case of the last cells in the battery, but is usually only one or two around the floating point.

The design of the switch is such that the moving contact *C* cannot stop except directly on one of the contacts *B*. As the moving contact travels from point to point to change the number of cells in circuit, it passes over the resistance contacts *R*, first short-circuiting through a resistance the group of cells that are to be added to or subtracted from the circuit. In this way the switch is moved from point to point without opening the circuit and without appreciable sparking.

In actual practice the motor-operated end-cell switches used in connection with large emergency batteries must have considerable auxiliary apparatus to make sure that they will accomplish everything that is expected of them in all emergencies and at the same time be foolproof under all conditions.

A large, modern, motor-operated end-cell switch installation is shown in Fig. 2. This consists of two separate switches, each having a continuous rating of 10,000 amp. The continuous rating of the end-cell switch should correspond to the one-hour rating of the battery. The overload capacity of the switch is then sufficient to handle any output that the battery can furnish. Thus if the battery is rated at 10,000 amp. for one hour and is capable of delivering 40,000 amp. for six minutes, the 10,000-amp. switch will carry the 40,000 amp. for six minutes and the traveling brushes can be moved from point to point under this 40,000-amp. load without injurious sparking even where three or four cells are connected between adjacent points.

Quite often two end-cell switches are installed in parallel on each side of a three-wire battery, each switch

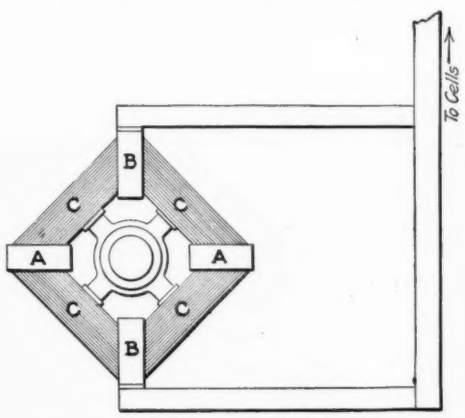


FIG. 3. MOVING CONTACT FOR END-CELL SWITCH

being capable of carrying the entire output of the battery. This provides a spare switch on each side and also permits floating the battery on a high- and low-voltage bus at the same time.

In large switches, such as shown in the illustration, the moving contact, or traveling brush as it is called, is made up of four parts in the form of a square, as shown in Fig. 3, fastened to a supporting frame in the center, which is moved as the screw revolves. At two opposite corners of this square are located copper busses *A* connected in parallel, which extend the full length of the switch and which connect to the station bus. At the other two corners are located the contacts *B*, to which the cells are connected by means of heavy copper bars running directly from these contacts to the busbar terminal on the cells. This design gives a large amount of contact surface and makes it practical to build switches for carrying the tremendous current which they are required to handle.

End-cell switches of this character as installed today are almost human in their operation. They are controlled from some distant point by a combined control switch and indicator, as shown in Fig. 4, which consists of a dial provided with a handwheel at the center and an opening at the top through which an illuminated number is seen corresponding to the number of the cell connected to the bus through the end-cell switch. By turning the handwheel, any desired number may be brought opposite the opening in the dial. The traveling brush immediately starts to move to the position indicated and stops when it arrives there, without any further attention from the operator. This is accomplished by a series of contacts on the back of the control switch in connection with a corresponding series of contacts at the end-cell switch. This control system is absolutely foolproof. The operator may set the dial at any number and then immediately change his mind and reset it at another point without waiting for the cell switch to reach the point first indicated. In fact, he may change the setting as often and as rapidly as he may desire in either direction and no harm will result, but the cell switch brush will finally arrive at the point indicated by the last setting.

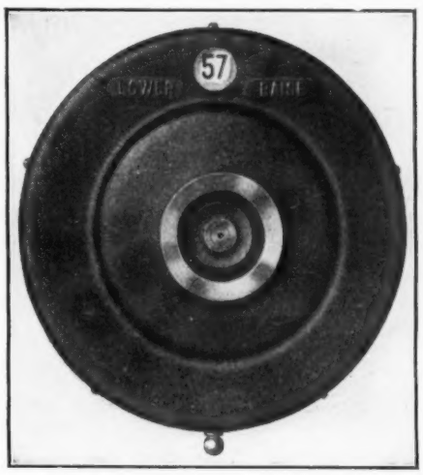


FIG. 4. CONTROL SWITCH AND INDICATOR

When it is desired to operate two end-cell switches in parallel, a set of interlocking gears are used that can be thrown in mesh with each motor drive by means of a lever, which also connects the two motors in parallel electrically. The two switches then operate simultaneously as one.

Switches of the design described are in use in a great many of the substations of the large lighting companies, such as the New York Edison Co. and the Commonwealth Edison Co., of Chicago, and as the storage batteries which these switches control are installed solely for emergency purposes, they must be absolutely reliable and must never fail to work. In actual practice they have for all practical purposes been found to be as reliable as the battery itself, which must necessarily be the most dependable of any of the equipment in the station, as it must always be available to give service when everything else fails.

Self-Oiling Bearings have the merit of using the same oil continuously without waste other than by slight vaporization and creeping, but proximity to a heated bearing keeps the oil at a higher temperature than it is at its best for lubricating.

Cleaning the Ammonia Charge at the End of the Season

By Dr. F. W. Frerichs*

SYNOPSIS—Tells how to clean the absorption and the compression systems' ammonia charge, how the charge is contaminated and what precautions to use when doing the job.

The object of overhauling an ice or refrigerating plant is to put it into such condition that it will do the most efficient work. Overhauling should be done at reasonable intervals, say once a year, and consists in cleaning the ammonia charge, cleaning the brine, cleaning all parts constituting the plant, repairing all defects in apparatus and machinery, testing all parts of the plant and recharging and getting ready for new work.

Any ammonia charge may be contaminated by dirt left in the system before charging or by contact with packing materials, gaskets and lubricants during operation. Gasoline and coal oil used for cleaning, soap or lard oil used for cutting threads on pipes, grease, wax or asphalt contained in packing and gaskets are among the materials that may impair the ammonia. Most frequently, however, a bad quality of compressor oil is responsible for deterioration of the ammonia charge. Liquid anhydrous ammonia is to some extent a solvent for many of these materials, some of which can be eliminated by redistilling the ammonia. This may be successfully done in the following manner before cleaning the machine:

Cleaning Ammonia from Compression Plant

Toward the end of the season run the ammonia charge down to a small volume, and upon stopping work in the plant transfer all the ammonia into the refrigerating coils. If there is more ammonia than can be conveniently worked in the refrigerating coils, store some of it in ammonia-shipping cylinders, returning it later to the freezing coils for reworking. Then close the expansion valves and detach the receiver from the feed line, leaving a valve near the receiver. Remove from the compressor all oil, clean the discharge pipe, condenser and receiver thoroughly by blowing steam through them and dry them by air while they are still hot. By running the compressor slowly, you can distill off most of the ammonia from the freezing coils, compressing it at the same time and accumulating it in the receiver, from which you may withdraw it for storage into shipping cylinders. Care should be taken to run the compressor so slowly that only ammonia vapors and no liquid anhydrous ammonia and oil can enter the suction pipe of the machine.

A good way of drawing off anhydrous ammonia from the receiver into shipping cylinders is as follows: Place the empty cylinder in a horizontal position upon the platform of a scale, turning it so that the valve stem points downward. Connect with the valve on the receiver, which previously was connected with the expansion valves, and open the valves near the receiver and the cylinder, whereupon the pressure in the system will force a small quantity of ammonia into the cylinder. Then close the valve near the receiver, and by opening a valve attached to a tee in the connecting line, relieve the pressure in the cylinder, thereby removing most of the air and cooling the cylinder by evaporating some of the ammonia contained in it. Upon closing the valve near the tee and opening the valve near the receiver, ammonia will flow freely into the shipping cylinder. To prevent bursting at slightly increased temperature, care should be taken that the cylinders are not overloaded. Cylinders 12 in. in diameter by 7 ft. long carry safely 150 lb.; cylinders 10 in. by 7 ft., 105 lb.; cylinders 10 in. by 4 ft., 55 lb. In this manner all the ammonia contained in the machine may be withdrawn gradually in a purified condition, the compressor taking it from the freezing coils to the condenser and through the receiver to the storage cylinders. If this is done, the plant is empty and is ready for cleaning.

The advantage of redistilling ammonia before recharging it into the system manifests itself by regular running at increased capacity, which means less wages and a smaller fuel bill per ton of ice.

To clean ammonia in the absorption system:

Toward the end of the season run the ammonia charge down to a small volume. Shut the valve between the generator and condenser, running at the same time all the liquid anhydrous ammonia from the receiver into the freezing coils. Store excess ammonia after filling freezing coils into ammonia-shipping cylinders. Then close the expansion valves, disconnect the liquid-feed pipe, leaving a valve on the receiver and disconnect also the pipe between the condenser and generator. Then the condenser and liquid receiver should be cleaned with steam in the usual manner. Reëstablish connection between the condenser and generator, and by operating the plant make as much liquid anyhdrous ammonia as you can, reducing the strength of all the aqua ammonia to the lowest possible degree, say 12 to 14 deg. Bé. Transfer the anhydrous ammonia into shipping cylinders as before described. Then close the valve near the receiver, and by opening a valve attached to a tee in the connecting line, relieve the pressure in the cylinder, thereby removing most of the air and cooling the cylinder by evaporating some of the ammonia contained in it. Upon closing the valve near the tee and opening the valve near the receiver, ammonia will flow freely into the cylinder.

Temporary Storage of Aqua Ammonia

Now fill the generator with weak aqua ammonia to the usual level and draw off all weak aqua ammonia from the absorber and exchanger into shipping drums for temporary storage. Clean the absorber by steam, being careful that all the iron rust is removed, and connect the absorber with the lower end of the condenser to collect weak aqua ammonia distilling from the generator upon heating it. Gradually pump all the dirty, weak aqua ammonia from the storage drums into the retort, continuing distillation until it is all redistilled, and store in clean shipping drums for use in recharging the plant.

*Vice-president, Herf & Frerichs Chemical Co., St. Louis, Mo.

South American Laws Regulating Hydro-Electric Enterprises

By Ludwig W. Schmidt

SYNOPSIS—The author summarizes the laws regulating hydro-electric enterprises in Argentina, Brazil, Chile, Colombia, Uruguay and Venezuela and points out how these laws affect water-rights concessions in these countries.

South American laws regulating hydro-electric enterprise are in many ways different from those in the United States. Concession seekers and promoters of hydro-electric enterprises should therefore obtain advice from those well versed in South American law before entering into agreements or buying water rights. A short review of the existing laws in the different countries is here given, for which generally the excellent collection of these laws by Phelan J. Eder, of New York, contained as an appendix to a lecture by Rome G. Brown, read before the Second Pan-American Scientific Congress, was followed.

In Argentina the ownership of the water powers is not entirely vested in the central government, but under certain conditions is held by the different states forming the republic. Therefore the concession seeker will have to apply to the government of the states for permission to use the water power of any river in their territory. This rule does not apply where the nation is the owner of the rights in question, such as the regulation of commerce. As the nation as such owns all the water rights, it has also the right of regulating the use of those waters. This rule, which protects in general the national water resources against waste, also allows the provincial governments to change their regulations with regard to the use of the water rights. It therefore gives those governments power likely to interfere with the interest of the concession holder. Differences between concession holders and the provincial governments frequently lead to litigation.

Water-Power Rights in Argentina

If the river is navigable, the absolute right of the provincial government to give a concession ceases and the central government has to be applied to for permission to erect a dam or to use part of the water for other purposes than those of shipping. The law, which in this way puts obstacles in the way of the promoter of hydro-electric enterprise, on the other hand has opened for him the possibility of carrying aqueducts over the property of others to supply power plants, etc. This right can be enforced by law. The claimant has to prove that he has the right to use the water and that it is required for industrial or other purposes. The owner has to be compensated, but the concessionaire has the satisfaction of knowing that his right is not subject to prescription and that contracts made to impair it are void. To facilitate the erection of power plants and the use of water in general, the government has been authorized by a law to contract for the work necessary for the development of power, the power plants to be operated by the government or to be leased to others for that purpose.

The water-power rights of Brazil, while generally following the same trend as those of Argentina, are somewhat different. For instance, the right-of-way for aqueducts is not to be found in the Brazilian law. On the other hand, there is a law of Dec. 31, 1903, which gives considerable support to hydro-electric power development. The government by this law is instructed to foster the utilization of hydro-electric power for transformation into electrical energy when applied to federal services. Any excess power from such installations may be granted for the furtherance of agricultural, industrial and other purposes. The government may also grant special privileges to companies or individuals engaged in public services. These concessions shall be free from customs or municipal charges. The president may grant to enterprises generating electricity from water power exemption from customs duties, and the right to expropriate land and make improvements necessary for the installation and carrying out of the service. This law has helped a good deal to foster the extension of hydro-electric enterprise in Brazil.

Chilean Water-Power Rights Laws

The law regulating the use of water power for hydro-electric and other purposes in Chile is still in the development. Generally, it tends to support this sort of enterprise and it has taken special care to help the small power plant. The investigation now being carried out by the Chilean government may lead finally to an extension of the present laws. Such extensions, however, most likely will not change very much the basic principles of the present law. The running waters in their natural bed are national property, but they cease to be so when they flow through an artificial channel. In this case they belong to the person owning the channel. Permits for using national water powers have to be taken out directly from the government and in some cases also from local authorities. It is therefore necessary to inquire into ownership of these rights.

Two laws, passed in 1904 and 1907, give the necessary protection to the concession holder and also preserve the water resources of the country against waste. The former law provides that water powers on national or fiscal property can be granted only by the president. The same law also regulates the laying of transmission cables. Concessions for these are granted for a period of twenty years for underground and for ten years for overhead cables. The latter law provides for the employment of water powers by owners of property adjacent to the river bed. This may be done either by constructing special channels or by the installation of machinery on the river banks. The law provides for compensation to the owners of water rights resulting from channels flowing through their property. It fixes a rate of payment, which shall not be less than 4 pesos ($2.04) and not more than 8 pesos ($4.08) per horsepower. It also provides for arbitration in case the parties cannot agree upon a fair price.

This law has opened a new water-power-development era in Chile, and concessions granted under it give the

holder reasonable security. To receive a concession it is necessary to state the site where the concession is desired and the quantity of water which the concessionaire desires to take. He has also to state where the river will be tapped and where the water will be returned to its former channel. Concessions as a rule provide that plans be submitted inside the period of a year and that the concession is subject to such changes as are incident to the regulations governing the use of water power.

The ownership of all waters in Colombia is vested in the nation, and concessions for the use of the waters for hydro-electric enterprises have to be obtained from the national government. The concession can be granted only when private rights are not interfered with. The owner of land through which a river flows has the right to use the waters of the river for any desired purpose provided it is returned to the river channel after it has been used. This right is limited by the rights of lower owners. Also the law secures the rights of public users against waste. A near-by city may claim water rights of a private owner if those rights are necessary for the benefit of the inhabitants of that city. Ownership on water rights can be transferred. Although Colombia offers excellent opportunities for hydro-electric development, water-power resources so far have not been used on a large scale. Consequently there has not been any necessity for making special regulations governing the use of water for hydro-electric stations. The government, however, has shown considerable interest in the development of this industry by granting special facilities to promoters.

The uniformity of interest in hydro-electric development which is found practically all over South America has led to a certain uniformity of laws. The similarity in the new laws regulating hydro-electric enterprises also results from the similarity of the intentions of the law givers. This, for instance, is the case where large waterways belong to different nations, as in the case of the rivers forming the La Plata system. Here are four states—Argentina, Brazil, Paraguay and Uruguay—interested in the development of the powers of this big river system.

Therefore it is not surprising to see that the Uruguayan laws are following in their general rules those of Argentina and Brazil. In Uruguay the navigable rivers are public property; this refers also to the banks of such rivers. Other running waters are regarded as public property for the purpose of water supply and the watering of animals, provided there is a public road giving access to them. The owner of property on either bank of a river not navigable has the right to install artificial structures and machinery for hydro-electrical purposes. If he is the owner of only one bank, he must not carry his machinery farther than to the middle of the river. Furthermore, he must not interfere with irrigation rights and the rights of lower industrial enterprises. The law of Uruguay provides for public arbitration in case water rights are demanded for public utilities. The Usinas Electricas del Estado has practically a monopoly for the distribution of energy for light and power in Uruguay.

In Venezuela adjacent owners have the right of using the water power as desired provided they return it to the river. The right to carry a viaduct across the property of another for a compensation is also recognized. The concession depends upon a grant from parliament, at least as far as navigable waters are concerned. The erection of dams and the construction of canals and aqueducts necessitate concessions by the municipalities, state or president as the case may be. Public and private property can be expropriated in case of public necessity.

Peru, Ecuador, Paraguay and Bolivia follow in general lines the laws in use in the other countries here mentioned.

Induction Voltage Regulators

SYNOPSIS—The different methods of regulating the voltage on distribution lines are discussed with special reference to the construction and operation of the induction type single-phase, feeder-voltage regulator.

One of the requisites for judging an electric service is the constancy of the voltage at the customer's meter. With the continued increase in capacity and length of transmission lines, it has become almost imperative that some means be used to maintain the voltage at different points on the feeder constant; also interconnecting transmission lines for distribution systems often require regulating equipment to equalize the voltage between systems and the connecting feeders.

There are four methods whereby voltage drop in a transmission or distribution system may be overcome:

1. By increasing the size of the copper in the line. The effect of the reactance is somewhat intensified by increasing the size of the conductors, consequently doubling the size of the conductor will decrease the voltage drop less than half and does not prevent overvoltage during light load.

2. By adjusting of the voltage at the generator station during peak load. This method is very unsatisfactory, and practically impossible where a network is being supplied. For this method to meet the conditions at all would mean that the peak load on all meters must occur at the same time and be off at the same time.

3. By the use of voltage taps on step-down transformers. Almost all modern transformers are supplied with a system of voltage taps from their windings whereby the secondary voltage may be varied over considerable range, the connection being used that best suits the particular load on the line. But this does not take care of the change in voltage due to change in the load on the system. Therefore, if the voltage is to be maintained constant at the customer's load, the taps will have to be continually changed.

4. By installing induction-type feeder voltage regulator. This piece of equipment is the most satisfactory method of compensating for the drop on the line and may be installed on the system at whatever point is most convenient. It is well adapted for automatic operation and may be used to either raise or lower the voltage. The voltage is varied in a smooth curve without any abrupt changes and without interrupting the circuit.

One of the simplest methods of varying the voltage in an alternating-current feeder is by means of a simple potential transformer connected as in Fig. 1; the secondary is connected in series in the line, with the primary connected across. Assume that the instantaneous polarity of the line is as indicated. This will cause a current to flow through the primary winding, as shown by the arrowheads. The voltage induced in the secondary is in opposition to that in the primary; therefore in this case the pressure induced in the secondary will be in the same direction as the line voltage and will increase the potential beyond the transformer.

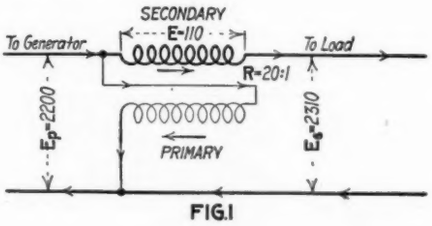


FIG. 1

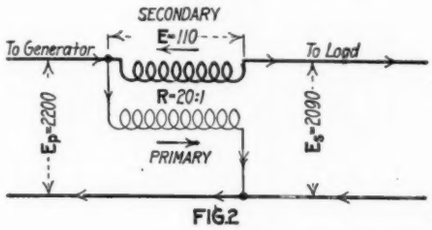


FIG. 2

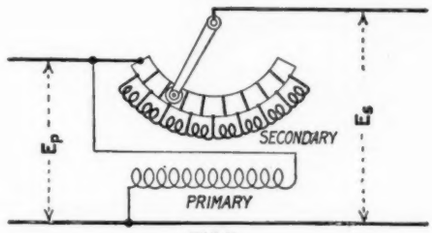


FIG. 3

The amount of increase of potential will depend upon the ratio of the transformer. A ratio of 20:1 will cause to be induced in the secondary $^1/_{20}$ of 2,200, or 110 volts, as shown. This added to the primary will give an electromotive force of 2,310 volts on the line beyond the transformer. Such a scheme is called a boosting transformer. If the primary leads are crossed as indicated in Fig. 2, the current through the primary will be reversed, consequently the voltage induced in the secondary. In this case the secondary voltage will oppose that of the line and will decrease it as shown.

Transformers have been used to some extent in the past to boost the voltage out on long distribution lines. One of the objections to this scheme is that the amount of boost or buck is practically constant, while the voltage drop in the line varies with the load. This difficulty could be overcome to a certain extent by bringing out a number of taps from the secondary to contact, as shown in Fig. 3, with an arm arranged so as to cut in or out a number of the secondary turns. Unless a large number of taps were brought out, the voltage would vary by jumps as each successive step was cut out or in. Nevertheless, this is the principle that the first alternating-current voltage regulators were built on.

As alternating systems became more extensive, a demand arose for a device that would maintain a good voltage regulation in the various parts of the network. This problem was solved by the introduction of the induction-type voltage regulator. The principle of this type of regulator is the same as that of the boosting transformer shown in Figs. 1 to 3. In the latter device, however, the primary winding is arranged so that it can be revolved through an angle.

A schematic arrangement of an induction voltage regulator is shown in Fig. 4. Assuming an instantaneous polarity of the line as shown, current will flow to the winding on the stationary secondary element *D* and the movable primary element *P*, as indicated by the arrowheads.

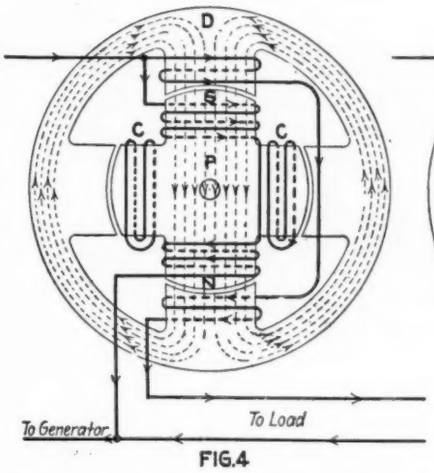


FIG. 4

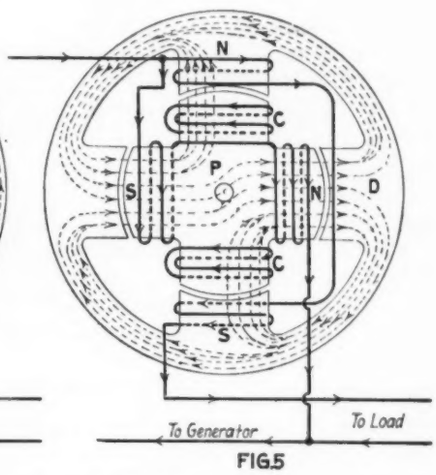
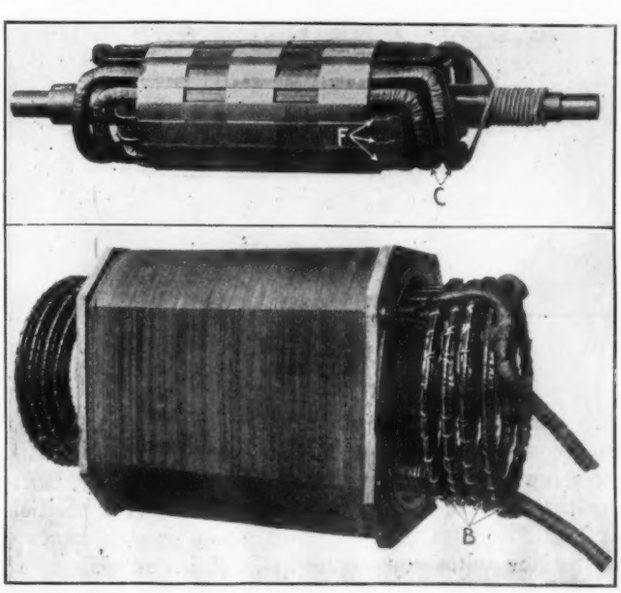


FIG. 5

FIGS. 1 TO 5. EXPLAINS THE OPERATION OF THE INDUCTION-TYPE VOLTAGE REGULATOR

From an examination of this connection it will be seen to be the same as that in Fig. 1; namely, a secondary winding in series in the line and a primary winding connected across the line, with the current flowing in the primary winding opposite to that in the secondary. Consequently the primary winding in Fig. 4 will induce a voltage in the secondary winding of the same direction



FIGS. 6 AND 7. ROTOR AND STATOR OF INDUCTION-TYPE FEEDER VOLTAGE REGULATOR

as the line potential, just as in Fig. 1, and the pressure on the service side of the regulator will be increased.

The primary winding in Fig. 4 is in a position to induce a maximum voltage in the secondary, because in this position all the lines of force set up by the primary pass through the secondary winding.

If the movable element is revolved through an angle of 90 deg., as shown in Fig. 5, the magnetic field set up by the primary winding will not pass through the secondary but around it, as indicated by the dotted lines and arrowheads. However, the secondary will tend to set up a flux, which is indicated by dotted lines looping through the secondary and one primary coil. This flux would induce a back pressure in the secondary winding if some means were not provided to neutralize it. This is the function that the coils *C* perform. It will be seen that each one of the coils marked *C* is short-circuited. Therefore the flux set up by the secondary will induce in them a current opposite to that in the secondary winding and neutralize the effect of the inductance in the secondary, just as short-circuiting the secondaries of a current transformer will neutralize the effect of the primary ampere turns. It will be seen that the coils *C* are ineffective in the position shown in Fig. 4, because none of the lines of force pass through them.

If the effect of the primary is maximum when in the position shown in Fig. 4 and zero in the position Fig. 5,

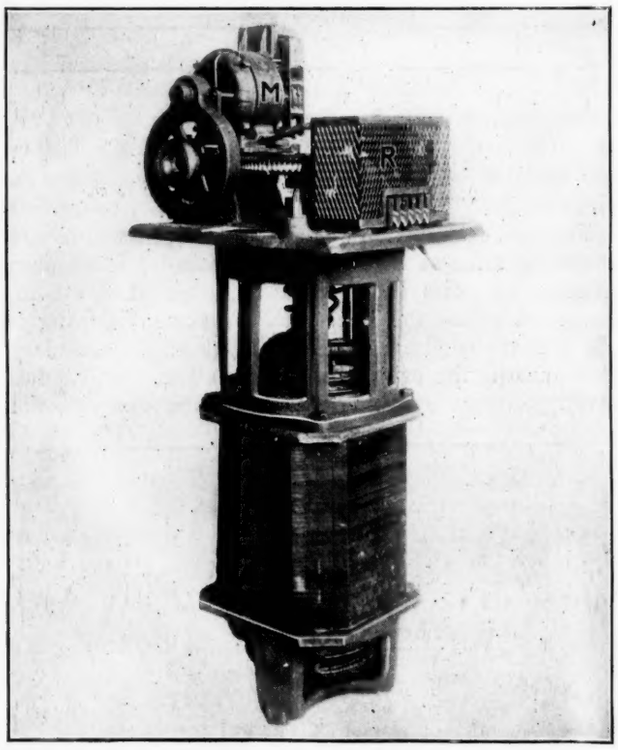


FIG. 8. REGULATOR ASSEMBLED WITH THE OIL TANK REMOVED

any intermediate position will give an effect according to the angular position of the primary winding with reference to that of the secondary. Consequently, turning the rotor in a clockwise direction from the position in Fig. 5 to that in Fig. 4 will give a smooth increase in the line voltage on the load side of the regulator. If the primary winding is turned through 90 deg. in a counter-clockwise direction from that in Fig. 5, it will then be connected opposite to that in Fig. 4; that is, the current will be flowing through the primary in the same direction as in the secondary, giving a condition similar to that shown in Fig. 2, consequently the secondary voltage on the load side of the regulator will be decreased.

In the construction of the induction-voltage regulator projecting polepieces are not used, as shown in Figs. 4 and 5; the windings are uniformly distributed like the

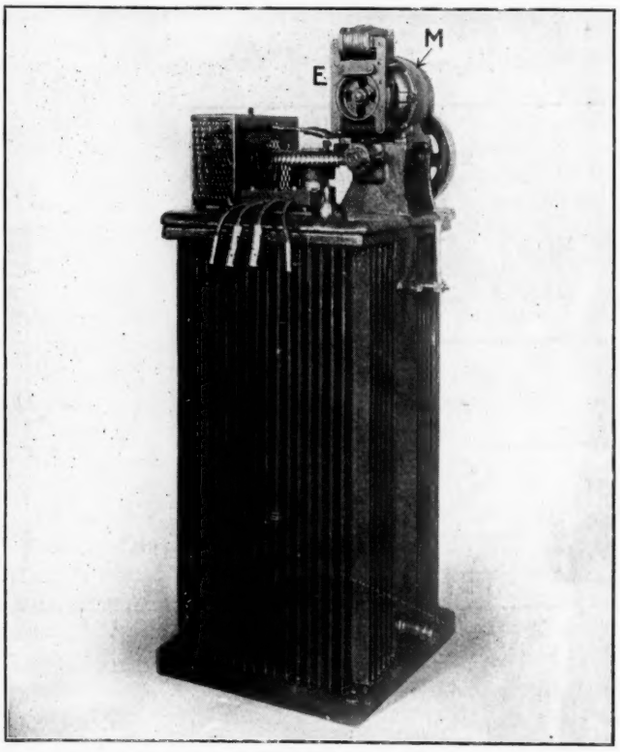


FIG. 9. INDUCTION-TYPE FEEDER VOLTAGE REGULATOR PLACED IN OIL TANK

windings in an induction motor. Fig. 7 shows the stator (secondary) core and winding and Fig. 6 the rotor (primary) of a new design of automatically controlled induction-type feeder-voltage regulator, built by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn. This is a single-phase induction regulator built for 2,300-volt 60-cycle 10 per cent. regulation and it is standardized in all ratings from 5.75 kv.-a. to 69 kv.-a. The rotor is wound with form-wound coils, as shown in Fig. 6, and constitutes the primary element. The short-circuiting coils *F*, in the rotor are formed from a large number of turns of relatively small-sized enameled copper wire, thus reducing the watts lost in these windings without decreasing the neutralizing effect for which they are provided. The primary coils are shown at *C*.

The stator core is of frameless construction, built up of laminated steel and clamped between steel end plates so largely used in the construction of induction motors. With this form of construction the cross-section of the stator core is increased without a corresponding increase in size of other parts and of floor space, resulting in a decrease of iron losses and exciting current. Furthermore, the insulating oil in which the regulator is immersed comes in direct contact with the various surfaces of the stator core with more effective cooling.

In regulators the insulation of the winding is of vital importance because of the severe conditions of operation.

The coils for both primary and secondary are therefore carefully insulated and impregnated and are assembled in open slots. They are held by fiber wedges driven in small grooves at the top edges of the slots. Heavily insulated steel bracing rings *B* are assembled around the exposed ends of the stator coils at both ends of the core. These rings are bound to the coils with cord and greatly stiffen the coils against distortion from mechanical shock caused by current surges in the feeder during periods of line disturbance or short-circuits. This feature is an important one, increasing the protection of the coil insulation and the factor of safety of the regulator in service.

In Fig. 8 is shown the regulator assembled with the oil tank removed. An electrically controlled switch or auxiliary relay *R* for the operating motor, formerly mounted separately from the regulator, is now mounted directly on the regulator top, as shown, and includes the limit switch. This arrangement cuts down the number of wires required in the control circuit for automatic operation and simplifies and lessens the expense of the installation. The chance of failure in the control circuit is correspondingly lessened as well, and inspection of the wire is made easy.

Fig. 9 shows the regulator placed in the oil tank. The motor *M* is provided with a quick-acting magnetic brake *E*, and the operating mechanism has been changed so that the regulator now requires only 10 sec. for a complete range of travel from maximum buck to maximum boost, 20 per cent. regulation.

The regulator is made as a unit, as shown in Fig. 8, and may be quickly removed from the tank by simply unbolting the top cover, thus making inspection and repairs comparatively simple. The tank is formed from sheet-steel walls, with oxyacetylene-welded seams and with top and bottom flanges cast to the walls. This type of tank is strong without undue weight and free from oil leakage.

Some Perpetual Motions

The perpetual-motion man is abroad in the land; the largest simultaneous appearance since the glowing accounts of his accomplishments incidental to the obituaries of the immortal Keeley suggested to numerous deluded or deluding followers the possibility of going and "doing" likewise.

The Power-Multiplying Machine

Fig. 1 is a reproduction of an illustration which appeared in an advertisement in several Texan and Mexican papers and which was reproduced on page 889 of our issue of June 20 last. As there shown, it seems to have been made from a photograph, which would indicate that one of the machines had actually been built. If this is a fact, the inventor and promotor must have found out that it would not multiply power as claimed, and would have hard work to justify the continued sale of stock in the project. No explanation is given of the process by which it is intended to controvert the principle of the conservation of energy by means of the aggregation of weights and levers shown. It seems that one has to supply some power anyhow; that this device simply multiplies what is supplied. To the obvious suggestion that some of the product might be shunted around to supply the place of the multiplicand, it would probably be objected that this would make it a perpetual-motion scheme in name as well as in effect.

Richard Ulram's Contribution

Richard Ulram, of Detroit, being duly sworn, deposes and says "that he invented Perpetual Motion and Power Machines of Millions of Horsepower Capacity; that he has Discovered the Secret, to Counterattract (Disattract) the Gravitation of the Earth—about 50 per cent.—at intervals; and further that he will pay One Thousand Dollars should he fail to prove this fact—at his demonstration—or if any one is able to disprove same."

Mr. Ulram, so one of our correspondents who has been favored by an interview reports, claims to be an Austrian, ten years in America. He is a carpenter by trade, and his inventive genius has been mostly employed heretofore in an honest effort to improve washing machines. He has no stock for sale, but is "raising" ten thousand dollars to construct a five-horsepower machine. A contribution of $50 entitles the party of the second part to $5,500 worth of stock in the corporation which will be formed after

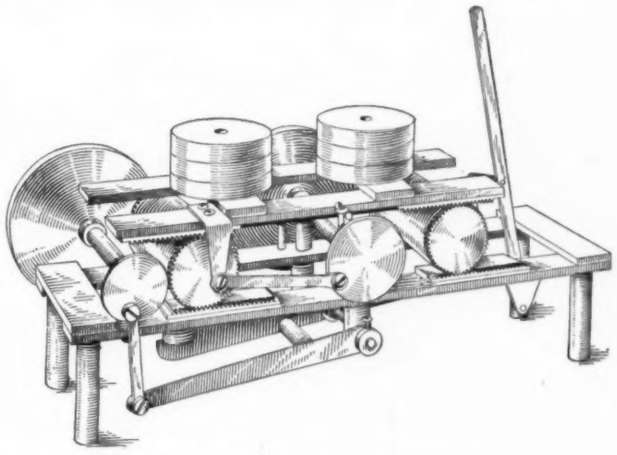


FIG. 1. THE "POWER MULTIPLIER"

the machine has been made and its practicability demonstrated. No time limit is specified, and Mr. Ulram will hold the "fifty" in the interim. He is taking no chances on using the mails, would not give our correspondent one of the blank contracts or discuss with him the principle involved in the invention. He gives "demonstrations" from 7:30 a.m. to 9 p.m.

There is usually some element of plausibility in the schemes which this genus of inventor (?) hatches, but if there is anything convincing in this one as set forth in Fig. 2, it evidently needs some of Mr. Ulram's personality to put it over. The only attempt at an elucidation in his literature is the following gem of lucidity:

> In other words the Earth attracts the whole weight when same drops. When same is lifted to its original position, I counteract the attraction of the Earth 62½ per cent. positively—that is 50 per cent. directly and 12½ indirectly. In other words, there is no attraction of the Earth on 62½ per cent. of the weights when same are lifted to their original start, but there is about 12½ per cent. of friction, so my actual gain of the weight dropping is about 50 per cent. net

On the editorial page of this issue a prize of $5 in addition to the usual honorarium is offered for the first and best attempt to unravel this skein of verbiage and explain what Mr. Ulram really thinks he has got.

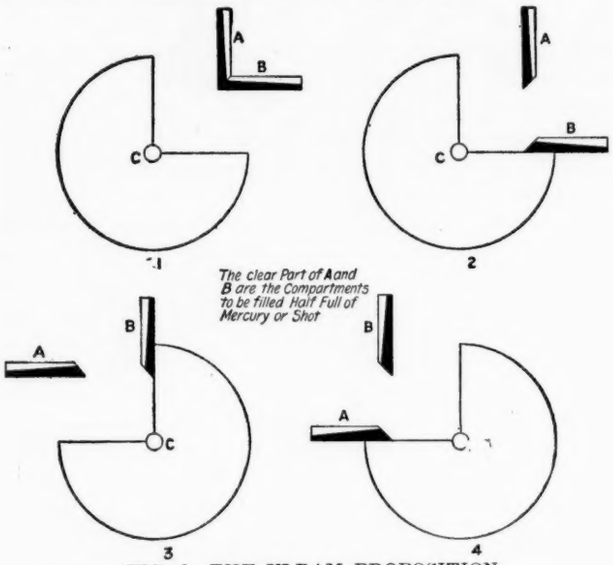


FIG. 2. THE ULRAM PROPOSITION
Reprint from page 732, "Power," Nov. 21, 1916

There is no trouble in seeing what Joseph E. Bissell, address not given, thinks he has found. The apparatus shown in Fig. 3 is rotated at 2,000 r.p.m., throwing the mercury in the vessel containing the balls into the outer leg, which it just fills. The balls in the mercury weigh less than nothing; on the contrary, they rise by their buoyancy. The ones in the empty leg have their full weight to induce their fall in the empty tube. What shall withhold them that they fall and push the little pinion around, which in turn shall drive the big pinion and the wheels of industry? Let the inventor tell his own story:

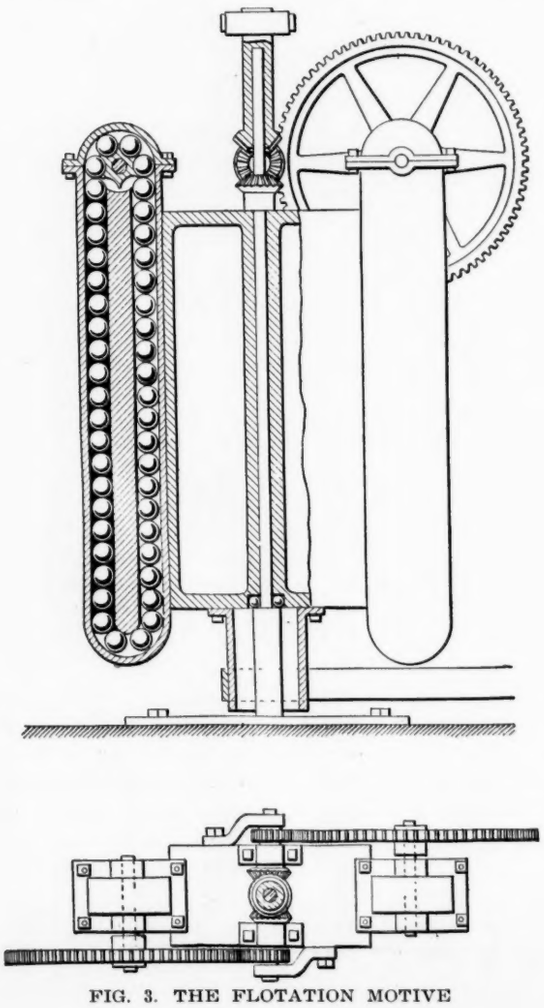


FIG. 3. THE FLOTATION MOTIVE

The whole apparatus is supposed to be spinning at 2,000 r.p.m., and one-half the space between the balls filled with mercury—the radius equals 3 ft. Then said mercury will stand perpendicular in the outer leg, between the balls, except for about one-sixteenth of an inch, or thereabouts, even if the balls are 6 in. in diameter, and the leg 138 in. high. The balls will displace about 75 lb. each, consequently there would be a constant pull of about 23x75, which equals 1,725 lb. lift to drive the balls past about one-sixteenth of an inch "out," from perfect balance. It is for the above reasons absurd to say Perpetual Motion is impossible, for it is possible, in spite of the long accepted notion to the contrary.
JOSEPH E. BISSELL.

Of course it won't work, but why won't it? *Power* offers a prize of $5 in addition to the usual honorarium for the first and best demonstration of the fallacy of this proposition.

The Cause of Many Accidents

By A. C. McHugh

The following might be used to illustrate several phases of human fallibility.

A new fireman had been instructed regularly every day for a week as to his duties when "changing over" and had apparently become familiar with what was required of him, so that he was allowed to go ahead without being watched and did very well for several days. One morning No. 3 engine was to be put on and No. 2 taken off. When No. 3 got up to speed, the engineer went to the switchboard and synchronized the two machines. The fireman was then given the signal to close the throttle of No. 2, which he started to do. When he had apparently half closed it, the engineer pulled No. 2 generator switch as usual, giving his time to regulating the voltage. His attention was attracted by the sound of No. 2, which seemed to be gaining speed, but upon seeing the fireman still at the throttle he thought nothing of it. As the sound increased he noticed the fireman was holding the valve wheel but making no attempt to turn it, although the engine was running away.

The switchboard is 75 ft. from the engine throttle, but the engineer (although no speed maniac) surely beat the world's record for 75 ft.—in a little less than no time. Four turns of the throttle and the danger was over. The shaft governor had failed to work, probably on account of some of its bearings being badly worn. A moment or two more and *Power* might be carrying an illustrated advertisement headed, "If this engine had been equipped with an automatic engine stop," etc.

When the fireman was asked why he had not closed the throttle, he explained: "After I had given the wheel several turns, I began to wonder whether I was turning it the right way or not: then I realized my responsibility and just couldn't turn it either way."

Throwing Water on Burning Oil spreads the flame and makes matters worse. Sand, flour or sawdust in sufficient quantities to smother the flame by excluding the air will extinguish an oil fire. Carbon tetrochloride acts in the same way.

Editorials

Power-House Design

The advancements that are being made in the design of large power stations and power-house machinery are so rapid that we scarcely have time to recover from our amazement at one great achievement in the field of this industrial activity when another feat of greater magnitude has been accomplished in the generation and utilization of electric power. Elsewhere in this issue is a description of the Essex power station of the Public Service Electric Company. In design and equipment this plant represents the latest achievement in power-house construction; every detail that goes to promote efficient operation and continuity of service has been incorporated.

Not so many years ago a boiler was considered well equipped, as far as indicating devices were concerned, when it had a steam gage and a water column. In this station, we find two steam gages, two water columns, two steam-flow meters, two feed-water regulators and two feed-water inlets. In addition to this, each boiler has a three-panel switchboard mounting draft and temperature gages, both recording and direct reading, and devices for controlling the draft and stoker equipment. All steam valves are electrically operated from the boiler-room floor, simply by the closing of a knife-switch. Instead of the wheelbarrow and shovel of bygone days, the coal is handled by an electrically operated larry and is weighed as it is distributed to the hoppers in front of the various boilers.

In the electrical features of the plant the same attention to details is found for keeping a complete record of the operation of the plant. Even the synchronoscope is a recording instrument. In addition to the various indicating instruments, each unit is equipped with a recording watt-hour meter, a recording ammeter, a recording temperature indicator, a recording voltmeter and a recording frequency meter, all synchronized every half-hour by a master clock. Twelve thermometer coils are located in each generator, and all indicate on a common instrument on the main switchboard.

It has been the general practice in power plants to discharge the heated air from the generators into the turbine room or outside the building—not so in the Essex plant; here it is discharged into the forced-draft fan room and used for the boiler furnaces, thereby recovering some of the energy lost in the generators.

Moreover, in this plant is found the most complete exciter system ever devised, consisting of three separate sources of excitation: A direct-driven exciter for regular service, with a storage battery for emergency so arranged that if the regular exciter fails, the battery is cut in automatically, after which a spare exciter is cut in parallel with the battery and the latter cut out.

One of the most pleasing features of the plant is the simplicity and flexibility of the layouts of both the electrical and steam systems. No one can study the diagram of the bus layout and the feed-water and economizer piping given in the article without being impressed with the fact that they are a criterion of simplicity.

With all the completeness of detail in construction and duplication of devices, this plant cost less per unit of capacity than any other ever installed. This is one thing that has characterized power-house construction for some years past; while the price of everything that is used in their construction has been steadily going up, the cost per unit capacity has been as steadily decreasing. This has been brought about only by improvements in the design of this class of machinery, so that today it is possible to install in a given space approximately five times the capacity that could be installed a few years ago, with the cost per unit capacity only about one-fifth, and with very little increase in cost per square foot of floor space occupied.

Perpetuum Mobile

There seems to be a veritable swarm of perpetual motions on the market. The several that we have alluded to in recent issues are only a part of those of which we have learned. Their promoters may be honestly deceived, but they are well enough informed to keep themselves immune from prosecution for obtaining money under false pretenses. Try to do business with one of them by letter and see him shy at using the United States mails. To such as are honestly deceived we suggest a reading of "The Perpetuum Mobile," written by Henry Dircks, and published in London in the middle of the last century, in which they will probably find the idea that is seducing them laid out beneath the analyst's scalpel, with its fallacy bared even to their bewitched vision.

It seems foolish and needless to repeatedly stigmatize these efforts to get the better of natural laws as at best hopeless infatuations; but whether they be knaves or fools, charlatans or self-deceiving dreamers, their promoters succeed in extracting a lot of money from people who can ill afford to lose it and in arousing hopes of fabulous returns impossible of realization.

It is just as impossible to create energy as it is to create matter, and it is morally certain that no machine can be made that will turn out more energy than is put into it. While this statement is safe and easy to make, it is not always so easy to point out convincingly just why a given scheme will not work; and it is an excellent exercise in elementary mechanics to analyze some of the more ingenious of these projects and put one's finger upon their weak points. The perpetual motion on page 757 is a case in point. Of course it will not work—but why? Can you point out which of the inventor's premises is false? If they are well founded, the machine ought to run and develop power. We know that it will not. *Power* will give a prize of five dollars in addition to the usual honorarium for the earliest and best demonstration of its fallacy. We will also give another prize of five dollars in addition to the usual honorarium to anybody who will explain why the perpetual motion now being exploited in Detroit by Richard Ulram and described on page 553 of our issue of Oct. 17 should ever be expected to run or upon what grounds it claims to overcome gravitation.

A Suggestion to the Societies

Most city and state boiler and refrigeration laws are so worded as to authorize the department head to allow or forbid the use of welded vessels for the pressures common in boiler and refrigeration work. Nearly all builders of refrigeration machinery make—though not exclusively, of course—coolers, receivers and such vessels, welded. It is to be expected that controversies will arise between the builder and the city official responsible for public safety from rupture of such welded vessels.

It is not surprising, therefore, to learn that Detroit, which lately adopted in a general way the Chicago refrigeration rules, is having its first little squabble with a Middle Western manufacturer over an autogenous-welded cooler which Chief Inspector McCabe refuses, or is reluctant, to approve. This is only a forerunner of the many controversies which are sure to come on the subject of welding for all kinds of pressure vessels. It is imperative that all interests involved do something to establish some definite means of meeting this condition, of giving us all a proper perspective of the factors that may influence our judgment.

Two of the largest societies most interested will hold their yearly meetings next week; namely, the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. It would indeed be regrettable to have these meetings end without this matter being given the attention it deserves.

⁂

Automatic Voltage Regulation

Voltage regulation is a problem that had its inception with the installation of the first generator for light and power purposes and has been increasing in importance down to the present day. The modern network of distribution lines made the maintaining of practically a constant voltage at the customers' meters a serious matter. In fact, it is the standard by which most users of electricity judge the quality of the service. Among the many results from low voltage are dim and flickering lights and variations in motor speed. Dim light or the flickering of lamps every time a motor starts causes great annoyance to those who have to work under these conditions. Variations in a motor's speed may occasion inconvenience in manufacturing processes, as well as cause a decrease in output. High voltage decreases the life of the lamp and may lead to overheating of other apparatus on the line.

There are various elements that affect the voltage regulation of a light or power circuit, such as the regulation of the prime movers, the electrical generator and the transformer, the size of the conductor in the distribution system, the wiring on the customer's premises and load conditions. In the large system networks generator and prime-mover regulation, as far as voltage control out on the line is concerned, becomes of little importance, for the voltage may be held constant at the station; yet out on the line during the peak loads it can be most anything, depending upon the drop in the conductors.

There are four ways by which the voltage drop in the line may be overcome to a greater or less extent. These are by increasing the size of the line conductors, by adjusting the voltage of the generator equipment, by voltage taps on the transformer and by the installation of automatic voltage regulators. The last has proved to be the only satisfactory means, as this device varies the voltage according to the load. It may be installed in the substation at the center of the load. This is satisfactory if the feeders are not too long. On long lines it becomes necessary to install the regulator out on the line.

The installation of additional equipment in many cases is looked upon as an unnecessary expense. However, in the case of the voltage regulator it generally leads to increasing the revenue and not the operating expenses. If the voltage is maintained constant at the customer's service, it results in an increased revenue derived from an increased consumption of energy by the various power-using devices on the line. This the customer is usually willing to pay if he gets an adequate service. A constant voltage also results in a decrease in lamp breakage, which is also to the central stations' advantage when they have to supply them free. Furthermore, an adequate service reduces to a minimum complaints from customers, which result in a reduction in the expense of keeping the customers satisfied. In most cases it can be shown that the additional returns are sufficient to justify the installation of automatic voltage regulators.

⁂

Do It Electrically

With the success of last year's electrical week fresh in mind, the electrical industries have again this year proclaimed December second to ninth as "America's Electrical Week" during which a nation-wide campaign will be conducted to do things electrically. While features of illumination will occupy a conspicuous part of the program, the major effort will be directed toward greater use of electricity in the home, including house-wiring and sales of domestic appliances. These may be small items individually, but collectively they are important factors in bettering the load conditions of the central stations. The present coal outlook and the general lowering of central-station rates as manifested during the past year should tend to lessen the gap between the cost of using coal or gas and electricity for domestic purposes and thus make the field even more promising than a year ago. We are living in an age of electricity and, irrespective of the source of supply, all encouragement should be given to extending its use. Greater use means higher development and should, although admittedly not always the case, mean cheaper electricity.

⁂

Effort to explain the low rate at which electric service is sold by some municipal companies on the ground that their stations are run by water power or cheap fuel is ridiculous. The station that was using over a half a cent's worth of fuel per kilowatt-hour would be ashamed of itself. If it would make a difference of only a half-cent whether the station had its fuel given to it or had to buy it, where is the sense of attempting to justify a difference in charge as between three and ten cents on the ground of cheaper power?

⁂

The other day the newspapers announced that Henry Ford had a new industrial scheme which he was going to apply to "dry" states. He proposes that the abandoned breweries be used for distilling alcohol for power purposes. We are glad to know that Mr. Ford approves the plan which a contributor to *Power* suggested long ago—in the July fourth issue of this year, page twenty-six.

Correspondence

Outside Help Beneficial

I was particularly interested in the last paragraph of your editorial, in the issue of Nov. 7, commenting upon the papers read at the Pittsfield convention. "It is up to him to run his plant so efficiently that no outsider can come in and take advantage of his inefficiency" is as true as anything you ever wrote. Why, then, do engineers so often resent the employment of a specialist to work with them in getting the best that there is out of their plants?

It is true that many an isolated plant has been put out of business that might have continued in existence if the same degree of skill had been applied to running it as was applied to shutting it down It is a "condition and not a theory," and I am not so sure but that the central station is really selling management and insurance against excessive cost and not merely electric current.

Providence, R. I. WARREN B. LEWIS.

Heating-Boiler Failure

Mr. Vickers described a failure of a heating boiler in the issue of Oct. 3, page 498, and stated that the probable cause was low water as a result of a vacuum being formed in some of the radiators by closing the inlet valve and leaving the return valve open, which drew the water out of the boiler. This condition has caused numerous boiler failures and is the result of carelessness or inexperienced workmen and improper inspection or none at all. A check valve should be placed in the return line near the boilers, for gravity feed, as shown in Fig. 1, in the same manner as on a high-pressure boiler feed line, and it is just as necessary to prevent emptying the boiler.

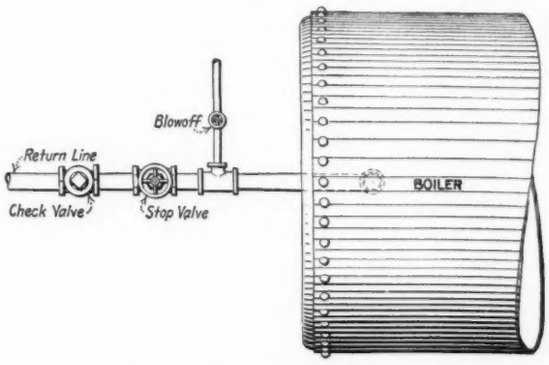


FIG. 1. CHECK AND STOP VALVE IN RETURN LINE

The Massachusetts and Ohio boiler rules provide for a check valve in the return line as follows: "The main return line to a heating boiler (gravity-return system) shall have a check valve and also a stop valve between the check valve and the boiler" (Fig. 1). "When there are two connected boilers (gravity-return system) one check valve may be placed on the main return pipe and a stop valve on the branch pipe to each boiler," as shown in Fig. 2. Where two boilers are used, one check valve may be used, as in Fig. 2, but it is preferable to have one on each boiler; for if one boiler is not required and the fire is drawn or banked, the water in the other boiler under pressure will be forced into the idle boiler unless the valve in the return line is closed.

The foregoing rules were embodied in the law to guard against such accidents as that described by Mr. Vickers,

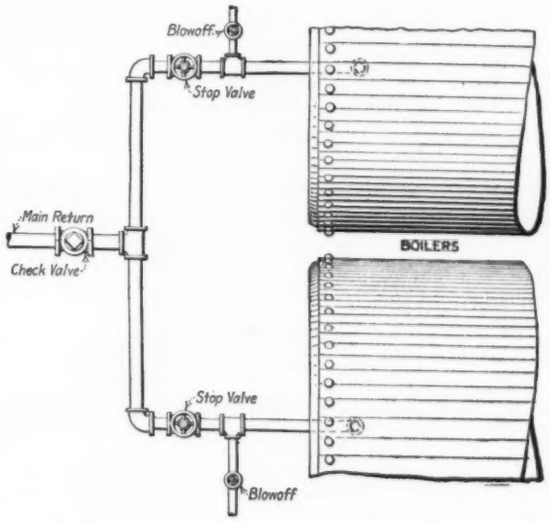


FIG. 2. CHECK VALVE ON COMMON RETURN TO BOILERS

and if the boiler had been installed in accordance with these rules, the failure might have been avoided. This is but one of many instances in which a boiler failure could have been prevented by effective boiler laws.

Hyattsville, Md. J. C. HAWKINS.

Removing Soot from Chimney

In a continuously operated plant situated in a thickly populated district, removing the accumulation of soot from the base of the chimney without giving cause for complaint from neighbors is quite a serious problem, especially if the chimney is large and has a strong draft.

In a large plant near Boston the soot is successfully removed from a 250-ft. chimney each year, by the admission of water through a 2-in. pipe extending into the base of the stack through the cleanout door. For convenience this pipe is made long enough to extend across the diameter of chimney with enough remaining outside to make it easy to handle; and as it is necessary to change its position from time to time, it should be attached to a length of fire hose. The cleanout door should have an opening at the bottom or be replaced by a cover of wood or metal to allow the pipe to enter and the water and soot to discharge. The soot is washed out from the bottom of the pile, and the surface is not disturbed, to cause it to be carried up the chimney. A. JACKSON.

Boston, Mass.

Rating and Guarantee of Small Centrifugal Machinery

I was much interested in reading, in the issue of Oct. 10, page 531, Charles M. Reed's criticism on my previous letter relative to guarantees of small centrifugal machinery. Instead, however, of showing that my assertions were based on a wrong or foolish hypothesis, his curves confirm what I tried to make clear.

Before analyzing Mr. Reed's curves in detail, I would like to refer to his statement as to whether I would really expect anyone to consider my estimate as to the number of tests required to obtain accurate data with any seriousness. I would refer him to the third paragraph of my article (Aug. 8, page 213) following the list of tests: "The absurdity of the whole proposition is at once apparent, but these figures are given just to show how much the majority of guarantees given must necessarily be based on interpolation."

Mr. Reed states that the series of tests he carried out in six days are sufficient to give an accurate estimate of the performance of this type of turbine. The question at once arises, What is an accurate estimate? Or rather, How accurate will the estimate be? I agree that the data derived from this series of tests will give an approximation that should be near enough for all commercial purposes with a machine of this size, and if the buying public could be satisfied with this estimate, then Mr. Reed's figures are more accurate than mine; but I do not think that he would be willing to give an absolute guarantee on a

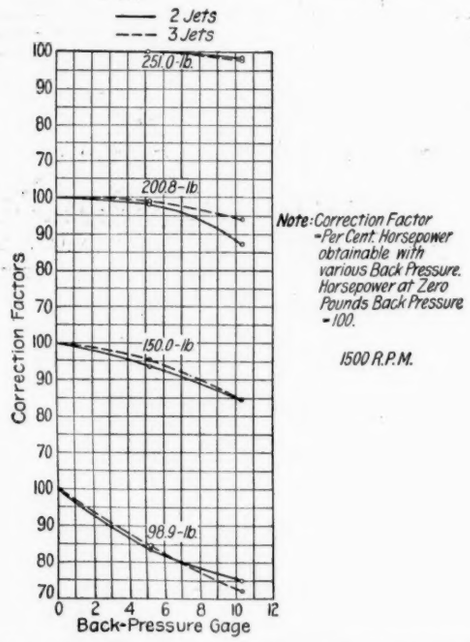


FIG. 1. BACK PRESSURE CORRECTION CURVES

duplicate machine with, say, 175 lb. initial and 3 lb. back pressure based on the so-called complete characteristic curves he obtained.

Unfortunately the curves published are to such a small scale that it is difficult to analyze them, and for this reason I appreciate that it is hardly fair to criticize them; but I think we can read some of them with sufficient accuracy to establish the point I wish to make.

From Figs. 1 and 2 of Mr. Reed's article, let us find the back-pressure correction factor for any other pressures than those given or plot a characteristic curve accurate enough to base guarantees on. Assuming 0 lb.-100 per cent. we get a series of curves as shown in Fig. 1. It will be seen that at 200 lb. the correction factor for 10.3 lb. back pressure is 0.875 with two jets and 0.94 with three jets. Yet at 150 lb. it is the same for two or three jets, and at 100 lb. the characteristic is reversed from

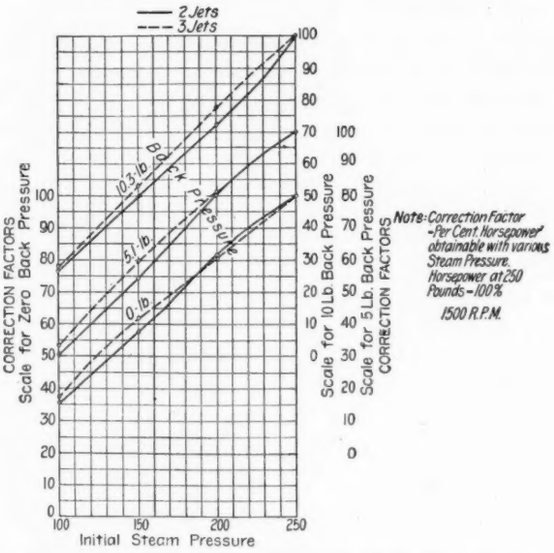

2 Jets
3 Jets
10.3-lb.
5.1-lb.
0-lb.
CORRECTION FACTORS Scale for Zero Back Pressure
Scale for 10 Lb. Back Pressure
Scale for 5 Lb. Back Pressure CORRECTION FACTORS
Initial Steam Pressure
Note: Correction Factor -Per Cent Horsepower obtainable with various Steam Pressure. Horsepower at 250 Pounds -100%
1500 R.P.M.

FIG. 2. STEAM PRESSURE CORRECTION CURVES

that at 200 lb. inasmuch as there is a lower factor here for three jets than there is for two. The same inconsistencies are apparent throughout.

The curve plotted on a steam-pressure basis (Fig. 2) also shows a somewhat different characteristic for two and three jets.

I will, of course, be accused of splitting hairs, and rightly so if we look at the matter in a broader sense. I agree that the curves published by Mr. Reed show very good representative series of tests and are quite accurate enough for all practical purposes; but unfortunately they are not close enough to use as characteristic curves for the basing of the close guarantees so often foolishly called for at the present time. I repeat that it is not fair to analyze the curves too critically on account of the small scale, but I think Mr. Reed will agree with me that they do show discrepancies up anywhere to 8 or 9 per cent. A mean curve therefore would indicate that these tests are accurate within 4 or 5 per cent. This should be quite close enough for machines of this size, but let us look at it from another standpoint. From curve Fig. 6, page 533, we get a water rate of about 65 lb. with 200 lb. steam pressure, at 1,500 r.p.m.; 4 per cent. variation from this gives 2.6 lb. either way. This is more than enough to win or lose an order. Take the acceptance test of a machine that is out this amount; for instance, United States Government work, with which Mr. Reed is no doubt familiar, Specification 17 G.5 calls for a water rate of 36 lb. on a 50-kw. set. If the water rate on test is 37.4, the machine is not accepted without a special dispensation from Washington.

If Mr. Reed will look up my original letter again and read the first paragraph under the heading, "All Guarantees Are Uncertain," on page 214, he will see that I tried to bring out the very point that his curves prove; namely, that one can get an approximation by a comparatively few

useful tests and interpolation, and that approximation should be accepted as near enough for all practical purposes. But to get guarantees that are absolute and within the accuracy so foolishly demanded by some customers at the present time, my original estimate should be raised to the *n*th power. W. J. A. LONDON.

Lynn, Mass.

Safety Head as Discharge Valve

I have been interested and somewhat mystified by the letter of H. A. Green on page 463 of the Sept. 26 issue. It is not clear how or why he should use the safety head of his two-cylinder 7x10½-in. Frick ammonia compressor as a discharge valve. It would seem that the article by A. G. Solomon on page 92 of the July 18 issue, on which Mr. Green comments, gives sound advice on the operation of these machines. I would be interested in hearing from Mr. Green as to where he "discovered" this method of operating that machine. So far as a rather extended study and experience goes, I have never seen such a plan tried and do not believe it would be approved by the makers of the machine. There is little doubt as to what must happen to this machine if operated in such a manner. In another part of his letter Mr. Green states that he sees no way to put a discharge valve in the head of the machine. This leaves one uncertain as to just what kind of machine he has. If it is the standard Frick machine as stated, it already has the valve of sufficient size for normal operation and there should be no need of putting a valve in the head.

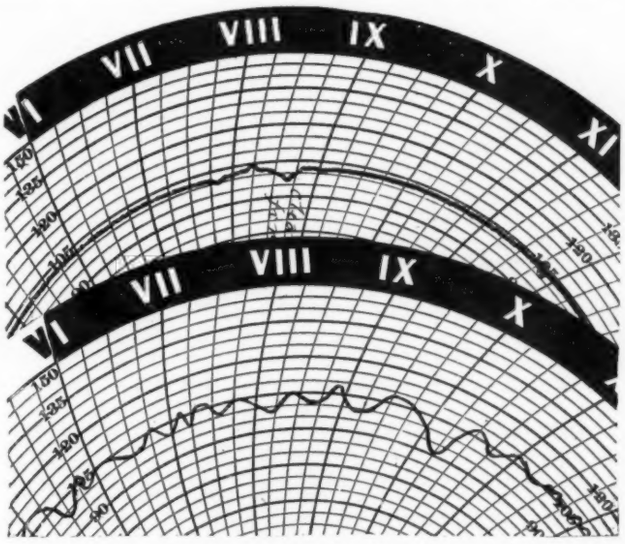
Mr. Green sees no apparent objections to his method of using the safety head as a discharge valve, so I think it may be of some benefit to discuss what seems to me to be the result that will almost certainly follow such operation. These safety heads are designed for the purpose implied in the name; that is, to make the machine safe in case of accident or any obstruction getting in the cylinder. Without such a provision a broken valve or bolt falling into the cylinder might easily cause the head to be broken off, with resulting loss and damage of ammonia escaping, not to speak of damage to the machine. Compressors are necessarily built with minimum clearance, in many cases not more than $\frac{1}{32}$ in. Wear or lost motion on the connecting-rod could easily cause the piston to push off the head. The safety head is designed to lift in such emergencies and thus avoid damage, but it is not designed to lift and properly seat itself at each stroke of the piston as a valve must do. If we consider the care with which valve areas and form of seat are designed and then consider that the safety head has no provision made for tight seating under quick action, it is readily appreciated that the functioning of such a head as a valve must be inefficient. Then there is the consideration of temperature and the relatively high condenser pressure. Under these conditions it is difficult enough to keep a well-designed valve in working order, without looking for trouble in trying to seat the whole head of the machine at each stroke. Heat will gum the oil and the head will not seat with equal pressure all around. Excess pressure at certain points will mean irregular wear on the end of the cylinder and on the circumference of the head. Soon a tight joint cannot be had and the output will drop so that the speed of the machine must be increased to maintain the desired room temperatures.

A leaky discharge valve is one of the most serious losses in compressor operation, and with a large head leaking, the trouble will be all the more apparent. Gas leaking in through the head, if in considerable quantity, may almost entirely prevent the inlet of gas through the suction valve for the whole stroke. Mr. Green's machine has probably not reached this stage as yet. His case seems to be one where the machine stands for the abuse for a certain time, as any good machine will stand a certain amount of ill use. If Mr. Green has a Frick machine with no discharge valve in the head, he should tell us more about it. Otherwise I would strongly advise him to see that the valves are in good condition, that the end of the cylinder and the face of the safety head are trued up and that the machine operates so as to leave them seated. It may be that excessive loss of oil has resulted in poor lubrication of the cylinder until it requires boring, as suggested. S. S. LEDBETTER.

Chicago, Ill.

Trouble with Fan Regulator

There are times when even the closest attention to the fires will not maintain an even steam pressure, and the trouble may be in any one of a number of places. The upper section of the chart shown in the illustration is from the recording steam gage in the office and is a fair average



TWO STEAM PRESSURE RECORDS; PILOT VALVE STUCK

of our daily practice; the lower one was made a few days after the forced-draft fan and stoker engine and the regulator had been overhauled and put in apparently first-class condition. For several days afterward the pressure was unsteady and the cause could not be ascertained. The standard-type damper regulator that controls the fan-engine speed had been taken apart for repairs. The cause of the fluctuating steam pressure was found in the pilot valve on the regulator, which had become sprung in screwing up on the unions connecting the water lines to it, causing the stem to bind in the packing and increasing the friction so that a greater force was necessary to operate it. This required an extra 5 lb. pressure or more to operate the valve. The unions were loosened and the pilot valve set plumb and held until the unions were drawn up tight. This operation took about a minute, and the

trouble disappeared. The regulator now acts on a variation of less than a pound. This was not a serious circumstance, but it is a good example of the necessity of attention to little things. J. C. HAWKINS.

Hyattsville, Md.

Abnormal Speed Variation

Sometimes power-plant troubles that are easy to remedy are difficult to locate. One case of this kind was when a 8x18-in. Corliss engine that gradually developed irregularity in speed or "hunting" to such an extent that it be-

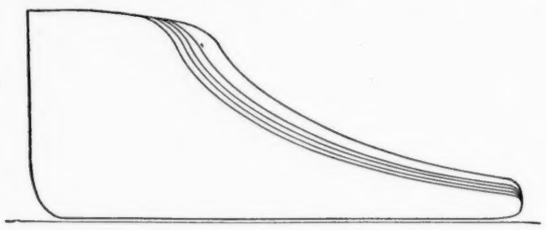


FIG. 1. DIAGRAMS DURING SPEED CHANGES

came necessary to temporarily abandon tests that were in progress because of the extreme variation in speed from one instant to the next. Indicator diagrams show a multiplicity of lines, as in Fig. 1, instead of a single well-defined diagram. In an attempt to secure smooth action, the prony brake was removed and thoroughly cleaned, the

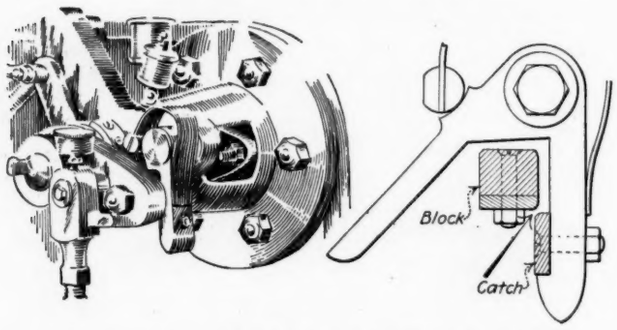


FIG. 2. CATCH AND BLOCK WORN AT CORNERS

governor belt cleaned and tightened and all joints in the governor linkage carefully inspected and oiled; but upon testing the engine again it was evident that the trouble had not been removed, and the matter was referred to the engine builders. Their reply was vague and evasive and consequently of no value. A few days later I discovered that the working edges of the hardened steel plates that engage to open the valves had become slightly rounded from wear, as shown in Fig. 2, causing the irregular action. Turning these pieces over so as to bring sharp edges into action gave the engine a new lease on life and it governed satisfactorily. L. A. WILSON.

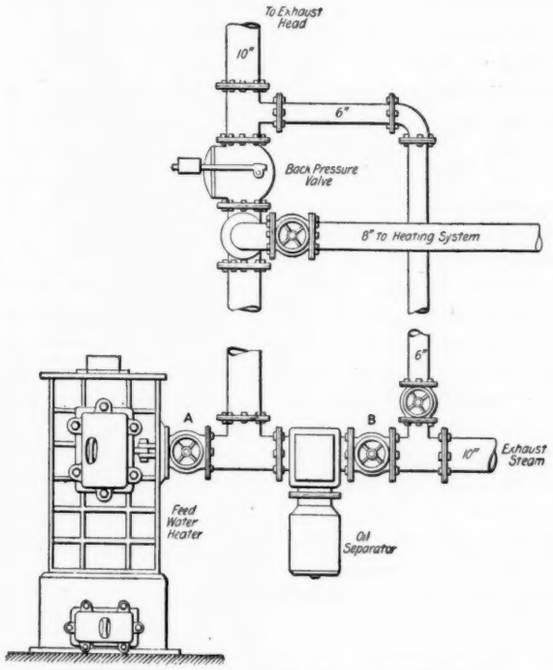
Urbana, Ill.

The Commutator has been referred to as the heart of the direct-current motor, both because all live current emanates therefrom and because trouble in the commutator will most quickly cause a cessation of all activity. Many a motor continues its existence for a long while with a bad commutator, as many a man with a weak heart lives to an old age, but neither is considered a good risk. Mechanical defects will cause poor commutation as readily as electrical ones. Motors that were sparking viciously have had the trouble entirely eliminated by tightening and turning down the commutator. Commutator troubles are cumulative, rapidly going from bad to worse.

Piping Separator and Heater

The illustration shows the exhaust connection to an open feed-water heater, an oil separator and a bypass, the piping being so arranged that either the heater or the separator may be cut out of service without interfering with the operation of the plant.

To cut the heater out of service so that the trays may be removed or the filter bed renewed, close valve *A* and the exhaust will pass to the heating system through the oil separator as during normal operation. When it is necessary to remove the trays from the separator, valves *A* and



PIPING FOR FLEXIBILITY IN OPERATION

B should be closed and the 6-in. valve opened. Steam then passes to the atmosphere and the heating system is cut off temporarily, but the number of valves is reduced to the minimum and the oil is effectively kept out of the heating system.

The best time to take the separator out of service is at night, when the heating demand is light and when only one unit would be running, so that bypass may be made small, keeping down the cost without employing inferior design.

It is not advisable to pass steam through this bypass for more extended periods than necessary, because the oily exhaust will leave a deposit which in time will interfere with the operation of the back-pressure valve.

It is perhaps unnecessary to suggest that the separator, back-pressure valve and exhaust head should be dripped, but contrary to usual practice, the latter two drips should be carried directly to the sewer with the rest of the oily drips.

This piping plan will cost slightly more than for a feed-water heater with a self-contained oil separator, but the advantage of being able to remove the plates of the separator without shutting down the plant will more than make up for the slight added initial expense in many instances. CARL P. MANN.

Beverly, N. J.

Inquiries of General Interest

"Seal Lap" of a Valve—What is meant by the term "seal lap" of a valve? L. B.

The term is sometimes used with reference to the lap that a valve has over the edge of a port to act as a seal against leakage when the valve is in a closed position.

Engine Friction Practically Constant for All Loads—How does the friction of an engine vary with an increase of load? D. A.

Experiments have shown that, under usual conditions and at all ordinary speeds and steam pressures, the friction of an engine remains practically constant and that the friction diagrams of the engine when unloaded represent also the friction of the engine whether partly or fully loaded.

Limitations of Revolving-Armature-Type Alternators—What is the highest voltage for which revolving-armature-type alternators are usually constructed? A. E. C.

The voltage of rotating armature alternators is limited to 2,300 volts on account of the difficulty of insulating the armature coils, collector rings and brush rigging. These limitations can be overcome, but the expense and additional maintenance cost does not warrant this type of construction.

Expansion of Brass Pipe—How much will 1-in. brass pipe expand per foot of its length for an increase of temperature from 60 deg. F. to 338 deg. F.? E. A. S.

The coefficient of linear expansion of rolled and of drawn brass is about 0.00001052 per deg. F. rise of temperature. Hence, if the rise of temperature is from 60 deg. F. to 338 deg. F., or 338 — 60 = 278 deg., the expansion per foot of length would be 278 × 0.00001052 = 0.00292456 ft., or about 0.035 in.

Polyphase Wattmeter on a Single-Phase Circuit—Will a polyphase indicating wattmeter read correctly when connected on a single-phase circuit? M. B. T.

If properly connected, a polyphase wattmeter will give a correct indication of the power transmitted in a single-phase circuit. This is obvious when it is considered that when the meter is connected in a polyphase circuit, at times one phase only may be loaded, but it will give a correct indication of the power transmitted in the single phase.

Reduced Voltage on Induction Motor—What effect would reducing the voltage 10 per cent. on an induction motor have on the starting torque? M. A. W.

The starting torque of an induction motor varies as the square of the voltage applied to its terminals. If it is assumed that the starting torque is 2.5 times full-load torque when 100 per cent. voltage is applied, then when starting on 0.9 normal voltage the torque will be 0.9 × 0.9 × 2.5 = 2.03 times full-load torque. This is equivalent to 19 per cent. reduction in the starting torque.

Inclined Floor of Combustion Chamber—In a return-tubular boiler setting what is the advantage of filling and sloping the space behind the bridge-wall? W. E. A.

When the space is paved, the principal advantage is in affording an inclined surface on which to draw deposits of cinders toward cleaning doors in the rear of the setting. But the arrangement is disadvantageous if the floor is raised much above the general floor line of the setting, as the space behind the bridge-wall should be open so that the gases may mix and eddy during their combustion.

Pounding of Corliss Exhaust Valves—In running a 16x42-in. Corliss engine at certain loads the exhaust valves pound badly. What may be the cause, and what is the remedy? L. J.

The pounding is probably due to expansion below the atmosphere causing the valves to be lifted from their seats by the excess of pressure beneath them. This may be remedied by throttling down the initial pressure so low that cutoff will be late enough to prevent expansion below atmospheric pressure; or the noise can usually be stopped by admitting a very small quantity of steam from one end of the cylinder to the other through the indicator connections.

Lap of Steam Valves of Duplex Pump—What amount of lap is given to the steam valves of a duplex pump? W. D. L.

The D slide valves are given only enough lap to cover the irregularities of the edges of the ports. Any more lap would increase the possibility of having both valves come to rest with all ports covered, under which conditions the pump could not be started by admitting steam to the steam chest. By having no lap to the valves, there is little likelihood of either valve coming to rest with both ports covered and the chance of both valves coming to rest with all steam ports covered is practically eliminated.

Reactance Coil Rating—Reactance coils are frequently used to limit the current from the generators to the busbars or from the busses to the feeders. These reactances are rated in percentage. What does this rating indicate? M. C. J.

The per cent. rating of a power-limiting reactance represents the percentage of normal line voltage that will be induced in it by full-load current. For example, a 5 per cent. reactance connected in a 6,600-volt circuit will have 6,600 × 0.05 = 330 volts induced in it with full-load current in the line. This means that the reactance will limit the current in the line to $\frac{6,600}{330}$ = 20 times full-load value.

Capacity of Staved Tank—What would be the capacity of a staved tank having inside dimensions of 12 ft. diameter at the bottom, 11 ft. diameter at the top and 10 ft. deep? T. R.

As the tank is of the form of a frustum of a right circular cone, the volume is given by the expression, $\frac{1}{12}\pi a(b^2 + c^2 + bc)$, where $\pi = 3.1416$, a is altitude and b and c are the diameters of the bases. As a = 10 ft., b = 12 ft. and c = 11 ft., by substitution the volume is found to be

$$\frac{3.1416}{12} \times 10 \times [(12 \times 12) + (11 \times 11) + (12 \times 11)] = 1,039.35 \text{ cu.ft., or}$$

$$1,039.35 \times 7.48 = 7,774.34 \text{ gal.}$$

Viscosity of Lubricating Oils—What is meant by the viscosity of a lubricating oil, and how is it tested? H. C. B.

Viscosity, or "body," is the quality of a lubricant that keeps the surfaces between which it is placed from coming in contact. The relative viscosity of oils can be roughly determined by shaking samples in bottles and observing the rapidity with which bubbles of equal size rise through the oils. Various kinds of viscosimeters are used, some of which give results based upon the flow of water, some upon the flow of pure rape oil, and others give results based upon the time required for a certain quantity of oil at a certain temperature to flow through the instrument.

Conductance, Susceptance and Admittance—What are the meanings of the electrical terms conductance, susceptance and admittance? A. A. F.

Conductance is the reciprocal of resistance; that is, if the resistance of a circuit is represented by R, then the conductance is $\frac{1}{R}$. Susceptanee is the reciprocal of reactance. Hence if the value of the reactance in a circuit is represented by X, the susceptance is $\frac{1}{X}$. Admittance is the vectorial sum of conductance and susceptance. It may also be expressed as the reciprocal of impedance. If the impedance of a circuit is shown by Z, then $\frac{1}{Z}$ is the admittance.

Allowance for Circular Form of Firebox—In estimating the strength of the furnace sheets of a vertical fire-tube boiler, what allowance is made for the resistance to collapsing that is offered by the circular form of the firebox? W. N. J.

Computations of the theoretical stresses in cylindrical shells subjected to external pressure are of but little practical value, as any departure from true circular form will introduce forces very much in excess of those originally calculated. Hence the allowable circumferential pitch of stay-bolts in the furnace sheets of a vertical tubular boiler is to be the same as the allowable pitch for stay-bolts on flat surfaces; and where the external diameter of the furnace is over 38 in., the allowable pitch for the stay-bolts both circumferentially and horizontally is to be taken the same as for stay-bolts on a flat surface.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Electric-Arc Welding

SYNOPSIS—Excerpts from a report of the subcommittee on electric welding, presented at the ninth annual convention of the Association of Railway Electrical Engineers, held in Chicago, Oct. 31 to Nov. 3. The different arc-welding processes are discussed and cost comparisons made with the oxyacetylene process.

The electric arc transforms electrical energy into heat. The heat is intense because a comparatively large amount of energy is transformed into heat in a small area. One kilowatt-hour of electrical energy is equivalent to 3,412 B.t.u. of heat. Thus an arc in which the current is 150 amp. and the voltage between electrodes is 20 will transform three kilowatts of electrical energy into 10,236 B.t.u. in one hour of continuous operation. Similarly, 1 cu.ft. of acetylene gas burned in oxygen will produce 1,555 B.t.u. of heat. Thus the three kilowatt-hours of electrical energy will furnish the same amount of heat as may be produced by approximately 6.6 cu.ft. of acetylene burned in 7.5 cu.ft. of oxygen.

The amount of heat which can be used in the arc-welding process depends largely on the size of the wire electrode being used. The kind of wire and the character of the piece being welded also affect this factor. The following table shows the limits indicated by present practice:

Kind of Electrode	Size, In.	Current	Voltage	Work
Mild steel.....	⅛	60–90	14–16	2-in. flues
Mild steel.....	3/16	110–140	16–20	5-in. flues filling
Mild steel.....	¼	150–180	18–25	Filling
Carbon.....	¼	250–350	35–50	Cutting—welding
Carbon.....	½	350–500	35–50	Cutting—welding

The electric-arc welding process (metal electrode) is, reduced to its simplest terms, a means of melting steel wire

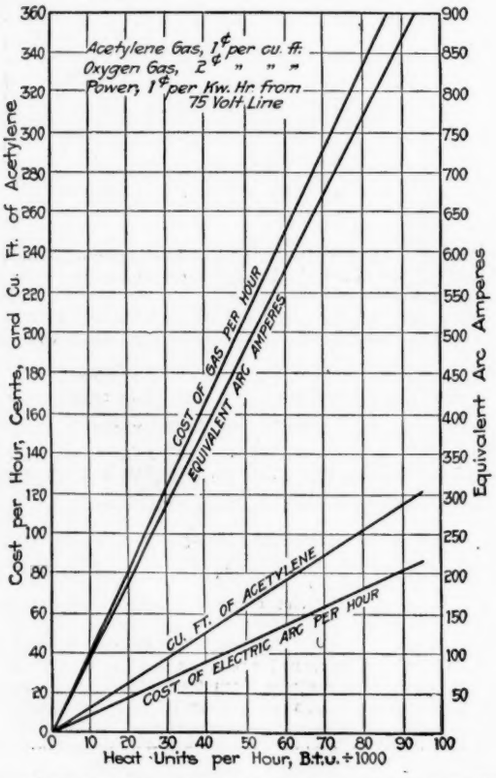

Acetylene Gas, 1¢ per cu. ft.
Oxygen Gas, 2¢ " " "
Power, 1¢ per Kw. Hr. from 75 Volt Line
COST OF GAS PER HOUR
EQUIVALENT ARC AMPERES
CU. FT. OF ACETYLENE
COST OF ELECTRIC ARC PER HOUR
Cost per Hour, Cents, and Cu. Ft. of Acetylene
Equivalent Arc Amperes
Heat Units per Hour, B.t.u. ÷ 1000

FIG. 1. COST OF GAS AND ELECTRIC WELDING BASED ON HEAT UNITS PER HOUR

and allowing it to flow while molten on another piece of steel which has been melted over a local area. There are three important changes that occur in the metal during the process:

1. The effect of mechanical treatment is entirely eliminated over the area heated to a plastic or molten state. The metal thus affected becomes cast steel.

2. Unless the molten metal is protected by a slag covering, it is oxidized to a certain extent by the oxygen present in the atmosphere. This oxidation tends to make the metal cold-short.

3. A large percentage of the impurities (carbon, manganese, nickel, vanadium, chromium, etc.), which may be present in the steel affected by the welding process before the

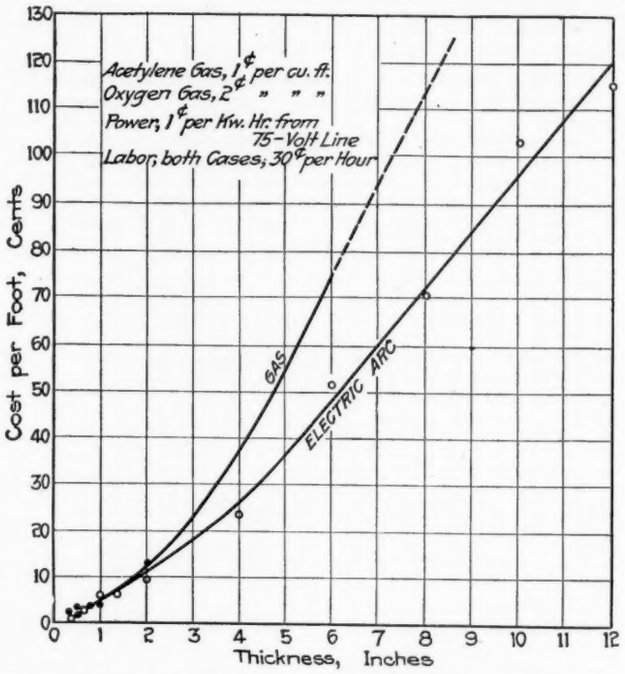

Acetylene Gas, 1¢ per cu. ft.
Oxygen Gas, 2¢ " " "
Power, 1¢ per Kw. Hr. from 75-Volt Line
Labor, both Cases, 30¢ per Hour
GAS
ELECTRIC ARC
Cost per Foot, Cents
Thickness, Inches

FIG. 2. RELATIVE COST OF CUTTING STEEL WITH GAS AND THE ELECTRIC ARC

operation, is vaporized or oxidized and has disappeared after the operation.

The net result is that in bare-wire welding, the metal obtained in the weld may be as high in tensile strength as the metal in the original piece being welded. It will be rather low in ductility, but will be soft if the metal before the operation was not over 0.35 per cent. in carbon content.

Up to the present time no method has been demonstrated of giving the cast steel in the weld the same characteristics to the same degree as those found in flange steel. The same tensile strength can be obtained and equal softness; but with the present development of the art of welding with the electric arc, equal ductility has not been produced. The cast steel in the weld may have practically the same characteristics as that used in locomotive construction so far as tensile strength, ductility and softness are concerned.

In spite of the comparatively low degree of ductility of the metal obtained in the weld, the process is entirely practical as a means of welding both cast steel and boiler plate, owing to the fact that the welded area may be reinforced where great resistance to fracture must be produced. The net result of this practice is to stiffen the welded section to such an extent that under severe stress the original and unwelded section will fail before the metal in the weld is strained to the point of rupture.

Welding in the firebox should be done with ⅛-in. or 5/32-in. electrode. The best metal is obtained in the weld with these sizes. The amount of heat is as small as can be economically used. It is evident that, owing to expansion and contraction difficulties, the quantity of heat it is possible to use in welding flues or firebox sheets is limited. The ideal preparation of a set of flues for welding is as follows: (1) Put flues in exactly as if they were not to be welded. (2) Fire the boiler or, better still, send the engine out for a run. The object is to burn the oil out from under the heads of the flues. (3) The flue-sheet should then be brushed with a stiff wire brush or sandblasted. The object is to eliminate, as far as possible, the scale of oxide on the flue-sheet and flues. Iron oxide is not a good conductor of electricity and causes difficulties with the arc, which in turn may produce a poor weld.

The welding of 2-in. flues is done best with a ⅛-in. electrode. On sandblasted flue-sheets 90 to 100 amp. is enough

current. Flue-sheets that have a thick coat of oxide require from 120 to 130 amp. on this size wire. Five-inch flues should be welded with a $\frac{5}{32}$-in. electrode with 120 to 140 amp., depending on the condition of the flue-sheet.

Cracks and patch seams offer the most difficult problems to the operator. A crack should be located and at least 2 in. beyond each end a ½-in. hole drilled. The edges of the crack should then be beveled so that the operator can get at them to make the weld. On horizontal cracks the lower edge does not need to be beveled, but should be chipped to give a square edge. The upper edge should be beveled at least 45 deg. Vertical cracks should be beveled from 30 to 45 deg. on each side. The less material removed from the crack the better. All welds should be made with the least possible amount of metal between the edges of the original material.

If the crack or seam is a long one, the metal should be put in alternate sections 4 in. to 6 in. long. The operator should put one layer of metal in each of these alternate sections, starting near the center of the seam or crack. The open sections can then be filled, starting at the coolest point. Successive layers of metal can then be applied until the seam is completed. Wherever possible, at least 30 per cent. of reinforcing should be applied so that the cross-section through the weld is 30 per cent. greater than the section of the original plate. After each layer of metal is welded into the seam, it should be thoroughly brushed with a stiff wire brush to remove as much of the oxide as possible. Where the sand-blast is available and can be used on the job, the results will justify the expenditure of time necessary to clean the metal between layers. The same general care should be taken in the welding of locomotive frames as in the case of the boiler plate of the firebox.

Aside from the use of judgment in the application of the electric-arc welding process, there are three rules which the operator must observe to get the best results in welding: (1) Hold a short arc. (2) Use a low current. (3) Always work on clean metal.

The accompanying cost data were obtained in one of the largest locomotive shops of the country; period covered, 7 months; cost of electric power, 2c. per kw.-hr.

The curves Figs. 1 and 2 give relative costs of cutting steel and welding by the electric arc and with gas.

The power required for electric-arc welding at the electrodes is low-voltage direct current. The metal arc requires from 75 to 180 amp. at 15 to 30 volts. The carbon arc requires from 250 to 400 amp. at 40 to 50 volts. The only object in using welding equipment is to get power of this nature economically. So far as welding is concerned, quite as good work can be done with resistance ballast across 250-volt direct current as is possible with the most refined and highly developed equipment.

There are two types of equipment on the market, which may be described as the constant-voltage type and the variable-voltage type. The former is a motor-generator set that takes power from the shop mains and delivers on the generator end a practically constant low voltage. A resistance ballast is used between the generator and the welding arc to limit the current at short-circuit. The power used in the resistance ballast is of course wasted. The low-voltage direct-current power is carried to the welding outlets in the different parts of the shop by heavy cables.

The variable-voltage type is a motor-generator set that takes power from the shop mains and delivers on the generator end the voltage required for welding without the use of resistance ballast. The inherent characteristics of the generator are such that the short-circuit current is limited without the use of resistance ballast. Inductive ballast is used to stabilize the arc. This type of equipment is made only in single-operator units. When using it, the low-voltage distribution system may be eliminated. The motor is fed directly from the shop lines.

Single-operator units of either type may be made portable. Large constant-voltage multiple-operator units must be located at definite points, although the resistance banks may be made portable if the low-voltage distribution system is made heavy enough to eliminate interference between operators due to line drop.

STATEMENT OF WORK PERFORMED WITH ELECTRIC WELDER AT LOCOMOTIVE SHOPS

1916	No. of Engines	No. of Flues Welded	Actual Time Welding, Hr.	Min.	Labor	Material	Current	Total Cost Actual Welding	Time Preparing for Welding Hr.	Min.	Cost Preparing for Welding	Total Cost to Engines	Average Cost per Engine
Total for 2-in. flues	247	42,640	2,811	15	$990.77	$181.09	$843.72	$2,015.58	222	45	$80.39	$2,095.97	$8.48
Total for 5-in. flues	196	5,034	1,473	45	520.01	85.47	442.16	1,047.64	24	00	10.08	1,057.72	5.39
Total for smoke-consumer tubes	244	1,946	122	00	42.85	9.76	36.60	89.21	.....		.....	89.21	0.37

MISCELLANEOUS JOBS

1916	No. of Operations	Labor	Material	Current	Total Cost	Other Method	Saving	Saving per Operation
January	461	$183.07	$47.88	$155.70	$386.65	$1,176.58	$789.93	$1.71
February	433	218.08	59.89	187.70	465.67	1,558.56	1,092.89	2.52
March	584	253.37	64.57	199.13	517.07	1,871.44	1,354.37	2.32
April	325	172.92	42.62	134.20	349.74	1,232,65	882.91	2.72
May	487	228.22	60.62	175.52	464.36	1,839.54	1,375.18	2.82
June	579	210.09	54.94	175.52	440.55	1,726.10	1,285.55	2.22
July	523	165.97	41.12	135.62	342.71	1,501.33	1,158.62	2.22
Totals	3,392	$1,431.72	$371.64	$1,163.39	$2,966.75	$10,906.20	$7,939.45	$2.36

Indicating Smoke Density on U.S.S. "Conyngham"*

By Rear Admiral R. T. Hall, U. S. N.

The system here described was installed on the afterstack of the U.S.S. "Conyngham" and consists of a light transmitter on one side of the stack, a light receiver on the opposite side and an indicator with suitable control appliances located in the boiler room. The indicator is provided with a scale of smoke densities, ranging from dark to clear (see Fig. 1).

This system was in successful operation during the official trial of the vessel and was found to operate satisfactorily under all conditions of smoke. Scale indications at various densities of smoke were checked by a member of the trial board with observations made visibly from the deck, and were found to be correct.

The basic principle of operation of the system is dependent on the peculiar property of the metal selenium, this metal, under certain conditions of crystalline structure, being light sensitive in its resistance to a passage of electric current; namely, of low resistance at higher light intensities, and vice versa of high resistance to lower light intensities. It will be manifest that if a beam of light be projected across a stack, its intensity will vary with the density of the smoke. If a plate of selenium of suitable structure is placed opposite to the source of projected light, its electrical resistance will also vary with the density of the smoke; and by connecting the selenium plate in series with a suitable indicating meter and a source of electric-current supply, such variations of

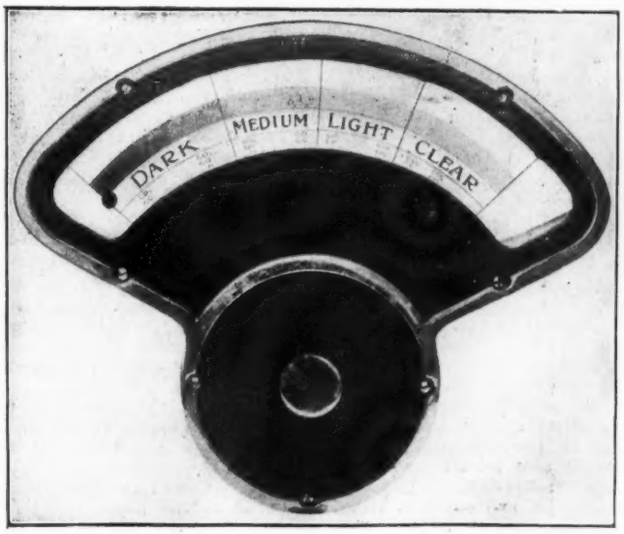


FIG. 1. INDICATOR SHOWS SMOKE DENSITY

*From a paper read at the twenty-fourth annual meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 16 and 17, 1916.

smoke density will be made manifest by variation in current flowing through a meter; and by suitably arranging the meter scale, such variations in electric current will be indicated as smoke densities.

The installation is shown in elevation and diagrammatically, in Fig. 2. In this figure, A designates a cast composition box rigidly secured to one side of the stack and B designates a cast composition box also rigidly secured to the stack, but diametrically opposite to A. The stack is provided with apertures, as shown in section. To the cover for box B is secured, and insulated from, the selenium plate. The glass

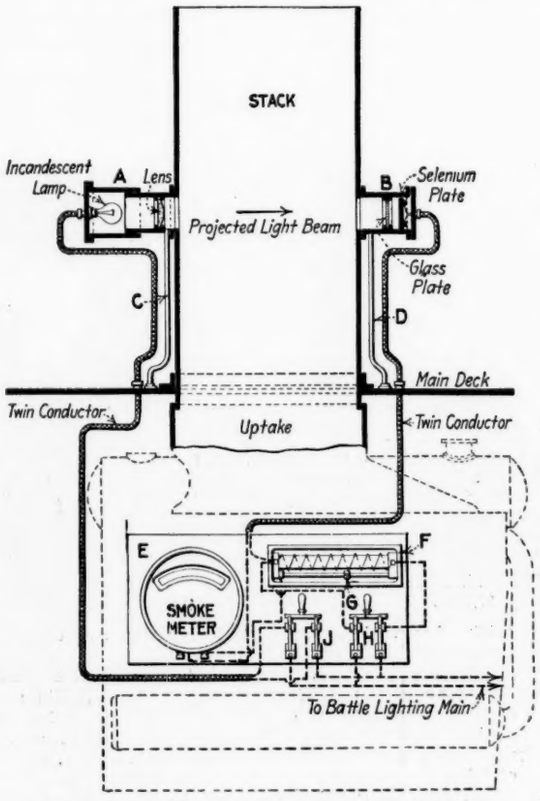


FIG. 2. LAYOUT OF SMOKE INDICATOR

pane is to protect the selenium plate from accumulation of dust, etc. Means are provided for cleaning the face of the pane nearest the stack if found necessary; C is a brass pipe leading from the boiler room through the box and to the stack, the function of which is to provide a steady stream of forced-draft air through the box and stack and thereby keep the box free from an accumulation of soot.

Box A is provided with a slidable sleeve to vary the focal distance of the incandescent lamp and lens. Means are provided on box A for locking the sleeve in place after the focal distance has been determined. The lens is rigidly secured to the box, and means are provided for cleaning it if necessary. A pipe D similar to C serves a similar purpose for box B.

A metal plate E is installed in the boiler room, in a location readily observable by attendants. On this plate is installed the smoke-indicating meter, whose scale is arranged in accordance with Fig. 1.

A potentiometer F also is installed on the plate. The potentiometer is provided with a slidable brush G for adjusting the potential on the selenium plate and serves as a simple and effective means for setting the indicator on the clear indication, as when no smoke is issuing from the stack. A switch H is rigidly secured to the plate, but insulated from it, and serves as a means of circuit control to the potentiometer and the selenium plate. A similar switch J controls the incandescent lamp.

The system is connected, as shown, to the ship's lighting main at 125 volts.

Babbitt Bearings—In motors for very heavy duty the pendulum seems to be swinging back toward babbitt bearings. A good babbitt bearing is more expensive than a good bronze one by 1 per cent. of the motor cost. A bearing babbitted with a high-grade tin babbitt calls for an increase of 0.6 per cent. over a cheap babbitt, but is a good investment.

Public Hearing on Boiler Code

Announcement has been made of a public hearing on the A. S. M. E. Boiler Code, commencing Friday, Dec. 8, at 2 p.m., in the Engineering Societies Building, New York, and continuing on Saturday and into the next week if occasion requires. This hearing is in pursuance of the following recommendation of the Boiler Code Committee to the Council:

Your Committee recommends that you appoint a permanent Committee to make such revisions as may be found desirable in these Rules, and to modify them as the state of the art advances, and that such Committee should hold meetings at least once in two years at which all interested parties may be heard.

In view of several matters of considerable importance having arisen in connection with the revision period, a technical session of the annual meeting of the Society will be devoted to the Boiler Code Committee, at which three or more papers will be read that pertain to boiler questions under discussion. These are as follows: Safety Valves, by E. F. Maas; The Talbot Boiler, by P. A. Talbot, and the Parker Boiler, by John C. Parker. Another paper on the subject of the pencil electrode method of electrode welding for boiler joints has also been offered. This session will be held Friday morning, Dec. 8, beginning at 10 a.m., and it is hoped that all interested in steam boiler problems in general and the A. S. M. E. Code in particular, will arrange to attend this session and discuss the papers. The public hearing will follow immediately after this technical session on the boiler subjects.

Recent Court Decisions

Digested by A. L. H. STREET

Slippery Conditions in Engine Rooms—A fireman employed in a steam-power plant has been declared by the Texas Court of Civil Appeals to be entitled to recover $7,500 for injuries sustained through slipping in a puddle of oil in a passageway near a moving engine, whereby he lost his balance and was permanently injured through falling against the driving rod; it being found that the defendant employer was guilty of negligence in permitting the puddle to remain where it was and in failing to have the place properly lighted. (Eureka Ice Co. vs. Buckaloo, 188 "Southwestern Reporter," 510.)

Power Expert as Witness—One of the principal exceptions to the general rule of law that a witness may testify only to specific facts known to him permits an expert to give a jury the benefit of his opinion on some point on which the jurors are not qualified to pass, because of want of technical knowledge or skill. Applying this exception in the recent case of Street vs. J. I. Case Threshing Machine Co., 188 "Southwestern Reporter," 726, the other day, the Texas Court of Civil Appeals decided that on a dispute as to power and capacity of an engine sold, a power expert who had seen other engines of the same kind work could properly give his opinion as to the capacity of such engines.

Maintaining Dangerous Electric Wires—A company, in erecting and maintaining electric transmission lines carrying heavy currents on or across a space through which telephone wires are strung, is legally bound to make approved and effective provision against communication of its current to the telephone wires. So held the West Virginia Supreme Court of Appeals in the recent case of Edmonds vs. Monongahela Valley Traction Co., 90 "Southeastern Reporter," 230, in which case there was affirmance of judgment for plaintiff for damages due to the killing of a horse in a public highway through contact with a telephone wire that had become heavily charged with electricity from one of defendant's high-tension wires.

"Water Mill" as Power Plant—A plant operated by water power for the generation of electricity must be deemed to be a "water mill" within the provisions of the Massachusetts statutes which authorize construction of water mills along nonnavigable streams and dams, according to a decision of the Supreme Judicial Court of the commonwealth handed down in the recent case of Duncan vs. New England Power Co., 113 "Northeastern Reporter," 781. The court further holds that it makes no difference on this point that the electricity may not be sold in the county where it is generated. "By the practice of a hundred years," says the court, "a water mill . . . includes mills for the manufacture of goods and the rolling of iron as well as for the grinding of corn."

Upon Taking Charge of a New Plant, do not begin by making promiscuous adjustments. It is better to wait a day or two until the apparatus is thoroughly understood, and then changes should be made only after the object to be attained is definitely known.

PERSONALS

L. G. Shepard, formerly with the Federal Sign System in Chicago, is now with the Milwaukee-Western Fuel Co., Milwaukee, Wis.

Walter C. Allen, electrical engineer of the District of Columbia, has been appointed executive officer of the District of Columbia Public Utilities Commission.

Francis P. Thrasher has been appointed superintendent of the Buzzards Bay Electric Co.'s plant at Chatham, Mass., his territory to include all the district east of South Yarmouth.

Thomas A. Ray has been assigned to the Boston office of the Edward Valve and Manufacturing Co. Mr. Ray is well known in engineering circles throughout New England because of his lecture and other educational work.

ENGINEERING AFFAIRS

The Pittsburgh Section of the Iron and Steel Electrical Engineers will hold a meeting on Dec. 9, under the direction of the standardization committee.

The Philadelphia Section of the Iron and Steel Electrical Engineers will hold a meeting on Dec. 2 at the Majestic Hotel. David M. Petty will present a paper on "Alternating-Current, Phase-Wound Motors versus Adjustable Speed Direct-Current Motors."

The American Association for the Advancement of Science and thirty or more national scientific societies affiliated with it, will meet in New York during the last week of December, under the auspices of Columbia University, New York University, the College of the City of New York, the American Museum of Natural History and many other educational and scientific institutions of the city.

The Combined Engineers' Associations of the N. A. S. E. of Brooklyn, held their ninth annual reception and entertainment on Saturday, Nov. 18, at Arcadia Hall. The attendance was the largest in the history of the organization, a conservative estimate would be 3,500. A pleasing entertainment preceded the dancing, and many prominent persons in the engineering field were present. The officers of the association are: S. A. Wright, chairman; Charles A. Enggren, vice-chairman; Walter F. Brundage, secretary; John P. Martin, financial secretary; George O. Kaley, treasurer; Charles Baxter, sergeant-at-arms. The combination comprises Nos. 8, 27, 41, 57 of the N. A. S. E. and the Modern Science Club.

Army and Navy Night for Chicago A. S. M. E.—Friday evening, Nov. 17, was Army and Navy night for the Chicago section of the American Society of Mechanical Engineers. It was the first meeting of the season, held as usual in the La Salle Hotel. Fully 200 were present. William A. Moffet, commandant of the Great Lakes Naval Training Station, told how naval cadets were prepared for the navy and with numerous lantern slides showed their quarters and features of the training. Beginning with the "Constitution" the development in ships of the navy was traced up to the last battleship off the ways. If we ever hope to gain naval supremacy, it was the speaker's opinion and plea that we must build ships larger, faster and with greater gun power than ever before. In other words, go the limit in the three features by which a battleship is rated. In this way the present-day dreadnaught or superdreadnaught would be outclassed and soon become obsolete and the nation with the most money to spend on naval equipment would gain the lead. Physical limits would be reached in a battleship having a displacement of 60,000 tons, 18-in. guns and a speed of 35 knots. Lucian B. Moody, major, ordnance department, Rock Island Arsenal, spoke on the army ordnance department, showing views of its factories and products and the guns now used by the army. In time of war the five arsenals would supply only a small part of the munitions needed. It would be necessary to depend largely on the output of private enterprises. Captain Christie of the new United States Aviation Station at Chicago outlined the methods of training aviators, the present status of the service and the hopes for the future. A review of the difficulties of the aviation corps in Mexico and personal anecdotes from the experience of the speaker were received with a great deal of interest.

COMBINED N. A. S. E. DINNER TO NATIONAL OFFICERS, TERRACE GARDEN, NEW YORK

The American Society of Refrigerating Engineers will hold its twelfth annual meeting, Dec. 4, 5 and 6, 1916, at the Engineering Societies Building, 29 W. 39th St., New York City. The following papers will be read: Monday afternoon, Dec. 4; "Data on the Ammonia and Water Mixer Specified in the Refrigeration Regulations of New York City," by Dr. Hermann Dannebaum; "A Theory of Cooling Towers Compared with Results in Practice," by R. H. Coffey and George A. Horne; "High-Rate Heat Transmission Through Externally and Internally Extended Surfaces of High-Duty Steam Boilers," by Enoch Rector. Monday evening: "Chemical Analysis and Testing of Commercial Anhydrous Ammonia," by E. C. McKeloy and C. S. Taylor, National Bureau of Standards; "Specific and Latent Heat of Anhydrous Ammonia," by Dr. H. C. Dickinson and N. S. Osborn, National Bureau of Standards; "Progress in Measurements of Physical Properties of Ammonia at National Bureau of Standards," by Dr. D. R. Harper. Tuesday, Dec. 5, 9:30 a.m.: "Oxyacetylene and Electric Welding," by Charles Hollup; "Accidents in Refrigerating Plants," by John E. Starr. Afternoon session, 1:30: "Low-Temperature Compression System," by Harry Sloan; "A Large High-Speed Ammonia Compressor," by C. R. Neelson; "Determining Heat Transmission of Compound Walls, with Tests on Insulated Steel Car Sections," by A. J. Wood. Evening: An Old Dominion beefsteak dinner, Murray's, 228 West 42nd St.,

$3.50 per cover. Wednesday, Dec. 6, 9:30 a.m.: "A Five-Hundred Ton High-Speed Booster Ammonia Compressor," by F. L. Fairbanks; "The Properties of Balsa Wood," by R. C. Carpenter. Afternoon session, 1:30: "The Present Status of the Thermodynamic Properties of Carbon Dioxide," by Dr. Frederick Keyes and Arthur W. Kenney. New Things in Refrigeration. Topical Discussions (to be taken up at sessions when time permits): Electric power for central stations for driving ice plants. In raw-water can ice-making systems using dehydrated air, is the fixed pipe in the can preferable to the bracketed pipe requiring its removal by thawing with steam? What is the best proportion in number of cans and square feet of pipe surface per ton of ice in a freezing system? Where an evaporative water-cooling system is used for cooling condensing water, is it better to use the tower for all the cooling effect or only to cool the water for the ammonia condensers and then use a spray water-cooling system for either steam condensing, in case of a condensing steam engine, or water jacket cooling in the case of internal-combustion engine? Hotel headquarters will be at the Hotel Astor, Broadway and 44th St., New York.

NEW PUBLICATIONS

LARGE ELECTRIC POWER STATIONS. By G. Klingenberg. D. Van Nostrand Co., New York. Cloth; 260 pages; 7¼x10 in.; 180 illustrations, including 7 plates; tables. Price, $5.

HOW TO BUILD UP FURNACE EFFICIENCY. By Joseph W. Hays. Tenth edition. Published by Joseph W. Hays, Rogers Park, Chicago, 1916. Paper; 7¼x5 in. Price $1.

This latest edition of this little book, so well known to engineers and firemen as to require no introduction here, is enlarged a trifle by the addition chiefly of matter that has not added appreciably to the value of that contained in previous editions. The idiosyncrasies of the author crop out and are manifested by homely quotations from "Down East Tales" and Omar Khayyam, which are unusual company for carbon dioxide and boiler efficiency; but no harm is done and the readers will enjoy them.

FIRST PRINCIPLES OF ELECTRICITY. By J. E. Homans. Published by Sully & Kleinteich, New York, 1916. Cloth; 5x7½ in.; 248 pages; illustrated. Price $1.

This book is intended to be used as a primer of electrical science or as a handbook of fundamental principles. The author starts with the assumption that the reader may be unlearned in the science of electricity and attempts to treat the subject from the ground up, passing in review all the matter necessary to constitute a fundamental knowledge of electricity and magnetism. This is one of the weak points in the work. An endeavor has been made to treat too many subjects in the allotted space, consequently the treatment must needs be superficial. The book may have merit for those who desire a general idea of electricity, magnetism and electrical machinery with a very limited amount of detail.

TRADE CATALOGS

Grinding Wheels. Star Corundum Wheel Co., Detroit, Mich. Catalog No. 9. Pp. 100; 6x9 in.; illustrated.

Giant Gas Engines. Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-X. Pp. 20; 6x9 in.; illustrated.

Link-Belt Silent Chain Transmitting Power in the Dye-Making Industry. Link-Belt Co., 39th St. and Stewart Ave., Chicago, Ill. Bulletin No. 282. Pp. 4; 6x9 in.; illustrated.

Water-Controlling Apparatus. Rodney-Hunt Machine Co., Orange, Mass. Catalog No. 30. Pp. 112; 6x9 in.; illustrated. This shows standpipes, gates and valves, flumes, etc., made by this company.

Single and Multistage Steam Turbines and Reduction Gears. Moore Steam Turbine Corp., Wellsville, N. Y. Bulletin No. 1. Pp. 12; 6x9 in.; illustrated. This describes a new line of turbines in sizes of 50 to 350 hp.

Inside Information. The Bruce-Macbeth Engine Co., 2111 Center St., Cleveland, Ohio. Booklet. Pp. 22; 6x9 in.; illustrated. This shows views of different engine rooms in which the Bruce-Macbeth gas engines are in use and contains facts as to results accomplished.

Water Cooling Devices. The Cooling Tower Co., 50 Broad St., New York. Loose Leaf Catalog No. 9. 9x11 in. Illustrated. This describes atmospheric, chimney and fan cooling towers, spray-nozzle systems and heat exchangers; their applications, operation and design being fully discussed.

Sturtevant Pneumatic Collecting and Conveying Systems. B. F. Sturtevant Co., Hyde Park, Boston, Mass. Catalog No. 235. Pp. 74; 8x11 in.; illustrated. This describes the Sturtevant fan systems for collecting dust and conveying materials and contains tables and other data which ought to be of use to those interested.

Proposed Construction

Ark., Coal Hill—Ferguson & Hicks plan to rebuild electric-light plant destroyed by fire.

Fla., Stuart—G. W. Parkes and associates considering plans for improving hydro-electric plant near Stuart.

Ga., Fayetteville—City soon votes on $15,000 bonds for improving electric-lighting system.

Ill., Chicago—City granted permit for a one-story steel and brick power house at 29th St. and Sacramento Ave. About $120,000. C. W. Kallal, architect.

Ill., Winnetka—City plans improving electric-light system.

Iowa, Dayton—Board of Railway Commissioners of Iowa granted Dayton franchises for electric transmission line between Harcourt and Dayton, Webster County; also installing electric-light system.

Kan., Bunker Hill—City plans street-lighting system.

Ky., Alexandria—Business Men's Club organized company to construct and operate an electric-light plant in Alexandria.

Ky., Murray—City voted $20,000 bonds for electric-light plant.

Maine, Lake View—The Lake View Electric Co., recently incorporated with capital stock of $5,000, plans electric-power plant to supply electricity in Lake View and Brownsville. E. H. Hamlin, Milo, president.

Maine, South Berwick—Berwick & Salmon Falls, Electric Co., Masonic Building, Dover, N. H., will build a power plant to include a concrete dam 240 ft. long and 16 ft. high. About $100,000. I. W. Jones, Milton, engineer.

Mass., Leominster—The Connecticut River Power Co. secured permission to install transmission line from southwestern part of city to Viscoloid Co.'s plant.

Mich., Milliken—Council soon to vote on franchise for electric-light system.

Minn., Duluth—Great Northern Power Co. authorized issue in bonds for improving and extending system, including electric transmission line from Thomson to Virginia.

Minn., St. Cloud—St. Cloud Public Service Co. making plans for an addition to its plant. C. L. Pillsbury Co., 805 Metropolitan Life Building, consulting engineer.

Mo., Joplin—Empire District Electric Co., Joplin, plans improving its Spring River power plant. About $25,000.

Neb., Odell—J. Barry plans to rebuild electric-light plant destroyed by fire.

N. J., Jersey City—The Public Service Electric Co. plans installing conduit system in Summit Ave.

N. Mex., Santa Fe—(Official)—C. G. Wilfong, Pres. Rio Grande Light, Heat and Power Co., 119 South 4th St., Philadelphia, receiving bids Jan. 2 for materials and work for hydro-electric development at mouth White Rock Canyon of Rio Grande River. A. G. Hillberg, Park Row Building, New York, engineer.

N. Y., Schenectady—The Schenectady Illuminating Co. has increased its capital stock from $3,000,000 to $5,000,000 and plans improving its system.

N. D., Flasher—H. Thornberg and J. Bunting granted franchise to install electric-light system.

Ohio, Cincinnati—The Union Gas and Electric Co. is spending $6,000,000 on improvements to its electric system. The improvements include the construction of a new power plant and the laying of about 40 mi. of 350,000 and 400,000-circ.mil. three-conductor cable. The initial installation includes two 31,150-kv.-a. three-phase 60-cycle 13,200-volt 1,800-r.p.m. generating units. Steam will be supplied to the turbines from 8 boilers, each having 12,600 sq.ft. of heating surface. Power will be delivered from the main station, at generator voltage, to eight substations. In addition to the motor-generator sets at present in the substations, there will be installed three 3,500-kw. synchronous converters. Sargent & Lundy, consulting engineers, Chicago, are in charge of the engineering work.

Ohio, Cleveland—Euclid-Dean Co., Euclid Ave. and East 105th St., plans power plant.

Okla., Beaver—City election Dec. 11 to vote on $8,000 electric-light plant bonds.

Okla., Durant—North American Light and Power Co. making plans for electric plant. About $18,000. W. A. Boehr, 22 South Michigan Ave., Chicago, Pres.

Ont., Grimsby—Radiest Electric Co. plans addition to plant. About $20,000.

Ore., Riddle—City voted $21,000 bonds for electric-light plant.

Penn., Philadelphia—L. H. Gilmer Co., Keystone and Cottman St., will build a power house. H. C. Eisenbise, Pennsylvania Building, architect.

Penn., Philadelphia—Plans are being prepared by the Endura Manufacturing Co., Eastwick Ave. and West 63rd St., for a one-story addition to its boiler house.

Penn., Topton—Borough defeated $7,000 electric-light plant bonds.

Penn., York—Preliminary plans are being prepared by J. B. Harmon, architect, 48 North Queen St., Lancaster, for a one-story boiler house for the Bell Motor Car Co., Center St. and Pennsylvania R.R. About $5,000.

Tex., Galveston—Galveston Electric Co. plans installing 300-kw. motor-generator in its plant at Galveston.

Vt., Hawkesbury—Riordon Pulp and Paper Co. plans addition to boiler house. About $30,000.

Va., Clarksville—Council plans issuing $7,500 bonds for electric-light system.

Wis., Park Falls—Flambeau Paper Co., of Park Falls, retained T. W. Orbison, architect, Appleton, to make plans for power dam, hydro-electric plant and paper mill on Flambeau River, near Park Falls. About $125,000.